ART. 7. WATERFOWL OF THE WESTERN PENNSYLVANIA SKYWAYS AS PORTRAYED BY THE MIGRANTS AT ONEIDA DAM, BUTLER COUNTY, PA.

By F. W. Preston

Director Preston Laboratories, Butler, Pa.

In Memory of Howard H. Elliott, who died suddenly in the fall of 1952 just before this report was completed

SUMMARY

The location, size, topography, date of construction, properties of the water, and other general data of Oneida Dam, Butler County, Pa., are outlined, with a brief description of its permanent flora and vertebrate fauna. Observations of its migratory waterfowl, especially ducks, over a four-year period, 1949-1952, inclusive, are given for both spring and fall migrations, involving approximately one hundred and twenty visits in spring and eighty in the fall. In particular, the number of individuals seen is reported.

The lake is used in the spring by more than three times the number of ducks that use it in fall.

It is used by far more males than females.

The great majority of the diving ducks, at least, are in flocks predominantly of one sex, usually males.

Forty per cent of all ducks are scaup, presumably Lesser Scaup.

The proportion of Black Duck to Mallards indicates that the lake is in the Atlantic Flyway for these species, and the frequent presence of swans and general absence of Blue Geese agrees with this. The azimuth of the swan's spring migration is noted.

The spring and autumn migrations are "independent" events and may conveniently be graduated by Gaussian curves. The peaks of the migrations are located, and their standard deviations determined.

The number of ducks to be expected at the peak, and the number of species, are determined, and the standard deviations of those numbers.

Tables of earliest and latest dates on both migrations, for most of the species, are provided. A few notes on unusual species and unusual dates are included.

An analysis of the number of Common Loons present on 38 separate occasions is consistent with the hypothesis that the species always migrates solitarily, even though a number may be present simultaneously on the Dam.

The number of "bird-days" (birds × days) *per season* is computed for both spring and fall migrations, for scaup and for "all ducks lumped together." (This gives a good estimate of the number of birds that were not observed because no one was there to observe them.)

ACKNOWLEDGMENTS

I wish to acknowledge the help, in the field, of John M. McCormick, formerly of the Preston Laboratories, on many of the early observations, and of the late Howard H. Elliott of Jamisonville, Butler County, who occasionally took over during my absences. The computations were made mostly by Mrs. Effie S. Young, and the compiling of the diagrams was also largely her

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work. The preparing of the graphs was done mostly by Miss Mary E. Gemperle, and the whole of the typing by my wife, Mrs. Jane E. Preston. I wish to thank P. H. Dowdell of the Butler Water Company for information on the size, date of construction, and properties of the water in the Dam, and for a list of the known fishes in it. I am indebted to Dr. O. E. Jennings, Director Emeritus of Carnegie Museum, for a special survey of the macroflora of the lake bottom, and to Dr. M. Graham Netting for identification of frogs and turtles. Finally, I am indebted to E. H. McClelland, formerly Technology Librarian of the Carnegie Library of Pittsburgh, now retired, for a great deal of help in arranging and editing the whole of the manuscript.

ONEIDA DAM AND THE WATERFOWL

Some forty years ago, in England, I asked my Greek and Latin professor, an excellent amateur ornithologist, how many species of birds he supposed one could see in my native town. "That depends," he said, "on whether you consider that the town extends '*usque ad caelum*' (up to the sky), for if you count the kinds that fly over us, but seem never to land here, it would be a very high total indeed."

The concept of the "flyways" is well known, largely due to Lincoln's work. I have avoided the term here and substituted the term "skyways," because I see little evidence that over Butler County there is any well defined direction into which the wild-fowl are channeled. The birds seem to go in all directions. It is true we have but little evidence all told, but such as it is, it indicates, I think, that the air above Butler County is, in the language of the aviators, simply a "navigable air space" that may be navigated in any direction whatever. This applies to the migrant wild-fowl on their spring and fall migrations, when one might expect the movement to be simply or predominantly a north or south one. But except that there is likely to be a northerly component to the migration in spring and a southerly one in fall, the movement seems to cover (at any one season) almost half of the horizon.

Thus, a loon migrating in spring over the Laboratory grounds was headed due north. A Bald Eagle in May, at a great altitude, was also headed due north; but a Bald Eagle in February was headed almost west (slightly north of west) on a course that would take it to Toledo. An American Egret was headed somewhat west of north on a course that would take it to Pymatuning. Seven wild Whistling Swans left Oneida and flew over Grove City on a true bearing of 322°; that is, 38° west of north, on a course that would take them over Pymatuning and Ashtabula, Ohio, on their way to the Mackenzie Delta. If they used the same course before reaching Oneida, they should have started from the coast somewhere near the Virginia Capes. On the other hand, banding returns collated by Carl Warren showed that many ducks were using a NE. to SW. flyway. Bonaparte's Gulls over Oneida in spring seem headed essentially west, with possibly a trace of south in their course. In the spring I have seen Ring-bill Gulls arrive at a local cemetery pond from the west, and again, over the Laboratory grounds, I have seen a large gull (probably a Herring Gull) also headed due east; but I have also seen several gulls (probably Ring-bills) in a flock headed due north just over our treetops. In the early spring I have seen a Merganser headed due west, also over the

Laboratory grounds, and various other ducks headed almost west. In the spring R. T. Norris reported seeing a large flock of Snow Geese over the grounds headed almost due north, while in the fall we have often seen Canada Geese headed due south. On the other hand, I have seen a large flock headed south-east and watched them for miles.

In many cases the weather was fair and visibility good, so there is no reason to suppose the birds were confused (as does happen in snowstorms), and it is to be presumed the birds were going in their normal courses. Therefore, I here treat the "navigable air space" as a pool of birds, flying more or less in all directions, and the problem is simply one of finding what that pool contains and when it contains it.

Oneida Dam (Fig. 1) five miles NE. of the center of the city of Butler, is a net for sampling the skyways. Its efficiency is no doubt different for different species, so it may not accurately reflect the content of the pool. But it is the best net we have, and it has some noteworthy advantages. It is the largest body of open water on the Foreland (the area between the Allegheny and Ohio rivers and the terminal moraine of the Wisconsin glaciation on the northwest) large enough to be occasionally acceptable to birds that normally prefer much larger bodies of water, but so small that no swimming bird can escape observation. And although it is so wide that birds near the far shore can not always be identified with certainty by binoculars, they can with a 20-power telescope, unless the light is poor.

It has the further advantage that there are virtually no resident waterfowl. In the winter there are none whatever, for the lake freezes over completely. In the summer there are virtually none. There are a few little Green Herons that no doubt nest near-by, and a pair or two of Kingfishers. Once in a while, but not every year, a pair of Black Duck will nest there. The Wood Duck and Mallard nest in Butler County, but we have no evidence that they nest at Oneida. Over the last 25 years, there have been occasional years when a few egrets (mostly American Egrets) have spent the summer there from July to September, but more years in which they are not seen and, generally speaking, the summer months might be said to be as blank as the winter ones.

Thus, ornithologically speaking, the lake has no existence apart from the skyways and is merely a device for sampling those skyways. This it does in spring from the middle of February to the end of May, and in the fall from September to November.

In the spring the dam is full of water, and the lake is accordingly attractive to waterfowl; in the fall, in many years, the water is very low, and extensive mud-flats are exposed at the upper (north) end. The lake is then attractive to shore birds, but much less so to waterfowl, though some visit it.

In the spring, the ducks and other waterfowl are anxious to press on to their breeding grounds in the north and west, and they seem to push as far north and west as they can find open water. There is therefore a concentration of birds against the edge of the retreating ice, as it were. When the weather is cold, snowy, or generally bad, if there is any open water at Oneida, birds will be found there, sitting on the water or on the ice by the water's edge. But if there is a sudden warming up of the weather, there is a

sudden drop in the bird population. Presumably they have gone north to the ice edge. The ducks are always scouting for this edge. I have seen a big flock of ducks come over Oneida when it was frozen from one end to the other. The birds would come over the hills and drop down as if to alight, fly the whole length of the lake, and then, finding no open space, would rise and continue their search, usually to the north.

The ice edge, however, is not the only controlling factor. At a time in the spring when the waters are open for many miles to the north or west, the birds may run into a line-squall. Since our weather moves from west to east and often forms a front extending SW. to NE., birds flying NW. in perfectly good weather may run into an impassable storm front. It is then a case of any port in a storm, and Oneida is such a port. This was the explanation of our greatest visit of Whistling Swans, 133 of them descending upon Oneida to escape a line-squall on April 1, 1949. Most of them left the next day, but seven remained, two of them (possibly slightly injured by their tussle with the storm) till April 23. Similar occasions frequently make it worth while to visit Oneida, and, generally speaking, when the weather is foul, it is good weather for ducks.

However, even this is not all. Oneida is a port of call as well as a port in a storm. This is particularly the case with the scaup (presumably mostly the Lesser Scaup) on spring migration. This is by far the commonest duck at Oneida, and it can be found there in good weather as well as bad throughout its migration season. While it is clear that birds of many species frequently stay only one day or even part of a day, there is reason to believe that the scaup frequently stays longer, flocks of identical numbers and identical sex ratio being sometimes seen for several consecutive days. To some extent this is true of other species, especially in the very early spring, with individuals that have arrived abnormally early. Thus, a solitary male Canvas-back was present at Oneida from February 16, 1951 to February 24, 1951, and there is no reason to doubt it was a single individual that arrived a long while (about three weeks) ahead of schedule. Similarly, on the small pond on the Laboratory grounds that we call the Carrie Dam, a male Ring-necked Duck was present from February 19 to February 27. Again, the bird was far ahead of normal schedule.

Oneida Dam is not shown on the present Butler, Pa., quadrangle of the U. S. Geological Survey (Fig. 1). This map was published in 1911, and reprinted in 1940, from surveys in 1908-1909. The map does show two other dams belonging to the same system, supplying water to the city of Butler and owned by the Butler Water Company. These other two dams are Boydstown and Thorn. Oneida lies on the same watercourse as Boydstown and extends from the foot of the Boydstown spillway to a point about a mile south. Though most of Oneida Lake lies northeast and southwest, or nearly so, the dam breast lies where the stream bends to the west, and the breast itself lies almost north and south. In the spring the Bonaparte Gulls seem always to come in at the north end of the lake, follow it south and then west as they pass over the breast. The level of the lake at the overflow is 1058.8 feet,* and the hills around it rise to 1300 feet. The country is shale

*Information supplied by P. H. Dowdell, Manager of the Butler Water Company.

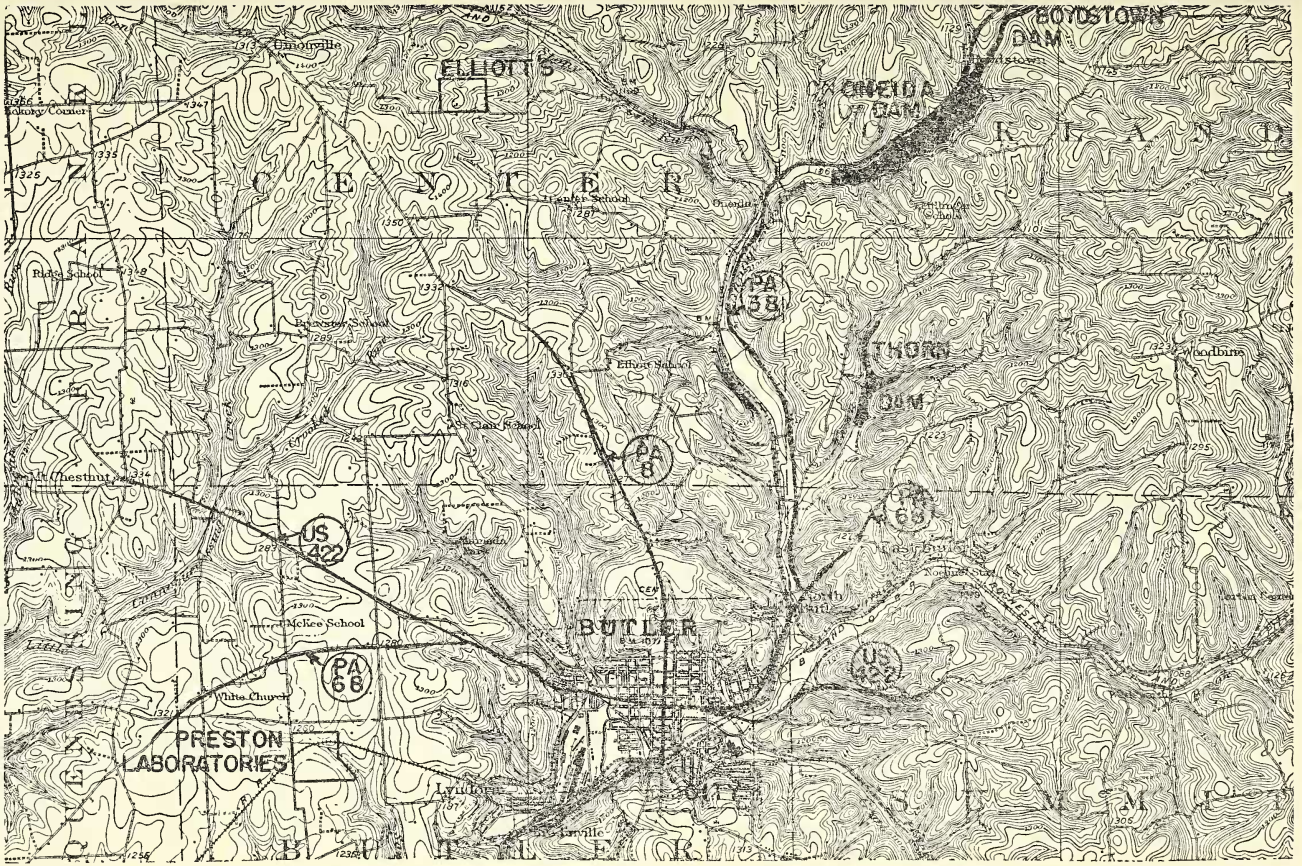

Fig. 1. Map showing Oneida Dam and other features, superimposed on Butler, Pa., quadrangle of U. S. Geological Survey

and sandstone of the Carboniferous (Pennsylvanian) system, and the lake lies well outside the glaciated area, about half way between the Wisconsin terminal moraine and the Allegheny River. Its position is indicated on the map.

The dam was constructed in 1918. In the intervening years a good deal of fine mud has collected in the upper, or north, end. This is a fine, sticky clay resembling the glacial muds of Muddy Creek, Butler County, and is many inches thick. The bottom of the south end of the lake, on the other hand, is sand and shale, much easier for human beings to walk on when the water is low, but much less attractive to shore birds. When the lake is full,* in spring, the dabbling ducks are, naturally, found almost entirely at the north end. The diving ducks are predominantly in the middle reaches, while mergansers, loons, and the like may be found over this same area and all the way to the breast of the dam. Fresh-water clams (*Anodonta grandis*) are plentiful in the mud, and painted turtles (*Chrysemys picta marginata*) are present in modest numbers. Years ago, there were some very large snapping turtles (*Chelydra serpentina*). Spring peepers (*Hyla crucifer crucifer*) seemed to be the diet of an American Egret that appeared on April 15, 1951, and stayed a day or two, and other species of frogs are known to be present, though no inventory of the amphibians and reptiles has been taken, and it is not known whether they form any significant part of the food of the birds. John M. McCormick observed bitterns feeding on frogs, and it is possible that the Little Green Herons use them to some extent. The fish include bass (some very large), and bluegills, sunfish, perch, and carp. Loons, mergansers, and Greater Yellow-legs have been seen to catch some of these.

Dr. O. E. Jennings (with Dr. L. K. Henry) examined the exposed mudflats on November 30, 1949, when the water was quite low. He divided the flats into three zones, beginning at "high-water mark," and continuing on into the water itself (zone 4). He reports the flora as follows:

Zone 1. Ordinary land plants. These evidently not much disturbed by inundations, which were probably of brief duration.

Zone 2. Rather firm mud apparently not covered by water since spring or early summer. A sedge (*Scirpus pauciflorus*) about 1-2 inches tall, forms extensive brown patches over the whole zone, with occasional plants of an *Eleocharis* (another member of the sedge family) commonly known as spike-rush; and also occasional plants of the low cudweed (*Gnaphalium uliginosum*), a common plant of muddy ditches.

Zone 3. This area was probably covered with water until late summer or early autumn. At the time of this visit it was soft mud. This area had rather extensive patches of the aquatic shallow water Naias (*Naias flexilis*), and occasional plants of the water-weed (*Elodea canadensis*), sometimes listed as *Anacharis* or *Philotria*.

Zone 4. In the water there were in places dense growths of the water-weed (*Elodea canadensis*) and a few pondweeds, mostly *Pota-*

*Capacity (original) 589,000,000 gallons. The *p*H of the water through the pipe-line at the filtration plant varies from 5.6 to 7.3; no information on its value in the lake itself. At the same point, the temperature varies during the year from 36° to 78° F.

mogeton diversifolius. At the inlet at the upper end of the lake the water was choked with masses of these plants, mostly *Elodea.*

Dr. Jennings adds that on an earlier visit, in August, he found that the pondweed (*Potamogeton*) had been fruiting abundantly. There is, therefore, some food for even vegetarian fowl, but Oneida seems to be less a feeding ground than a resting ground, and the ducks are often observed to be floating asleep, or sitting asleep on the ice or the shore.

OBSERVATIONS HERE REPORTED

Although I have some acquaintance with Oneida extending back almost thirty years, the observations here reported are confined to a four-year period, the years 1949 to 1952, inclusive.* In these years the work was essentially quantitative. An attempt was made, on most occasions, to get an exact count of every species that was present. Usually that was not difficult, for the waterfowl were sometimes less than a dozen individuals, and only rarely did they exceed a hundred. None the less, it was not always possible, perhaps because the birds were continually flying up and down the lake, or diving a great deal, or because the light was poor, or for other reasons. It is believed that very few mistakes in identification have been made, and that these few are probably not important in the general picture. Visits could not be made every day, and the period of observation on any one day was usually not more than 30 to 60 minutes. The object was not to ascertain every bird that visited the Dam in the course of a day, but to get an "instantaneous" sample of the skyway pool. On some days the picture changed from hour to hour, but when more than one visit was made on any given day, only one visit is taken into account for our present purpose. On most occasions the lake was examined with good binoculars and with a 20-power spotting telescope. For the most part this was done simply from the west bank, where Pennsylvania state highway 38 passes close by the shore, and usually in the late afternoon, as the light is then best.

The observations are almost entirely mine, but I had the company on many occasions of J. M. McCormick in 1949 and 1950, of young James Glenn, in 1951 and 1952, and of Mrs. Preston in all four years. In March 1951, when it was certain that I must be away for several weeks, the late Howard Elliott undertook to visit the Dam and keep a quantitative account, and his results for the last three weeks of March in that year are included in most of what follows. Except for this, no results are included except those obtained when I was personally present.

The spring migration. The object here was to determine the duration of the migration, *for ducks only*; to determine the peak of that migration, and to estimate the most likely number of individuals that would be seen on any given date within that period. It is shown that all this can be represented fairly well by a Gaussian "normal" curve. A further object is to determine the most likely number of species to be found on a visit on any day within this period. For this purpose the species are expanded to include

*A few notes of later date added while this article was in proof.

the ducks, geese, swans, loons, grebes, coots, gulls, terns, egrets, and herons. Excluded (on the spring migration, for this section of the investigation) are shore birds, ospreys and eagles, kingfishers, and passerines. This arrangement is somewhat arbitrary, but some definition of "waterfowl" is necessary. It might have been well to exclude the Little Green Heron, since it is not part of the skyway pool, but a summer resident. However, this was not done, and it makes only a slight difference.

Fig. 2 shows a scatter-plot of every available observation for the four years during the spring migration, giving the total count of ducks on the lake at each visit. In this figure the abscissa represents the date, regarded as so many days after January 31 of each year. The ordinate is the number of birds seen on each date, plotted logarithmically. This is a convenient way to plot numbers that fluctuate widely, and where the significant thing is

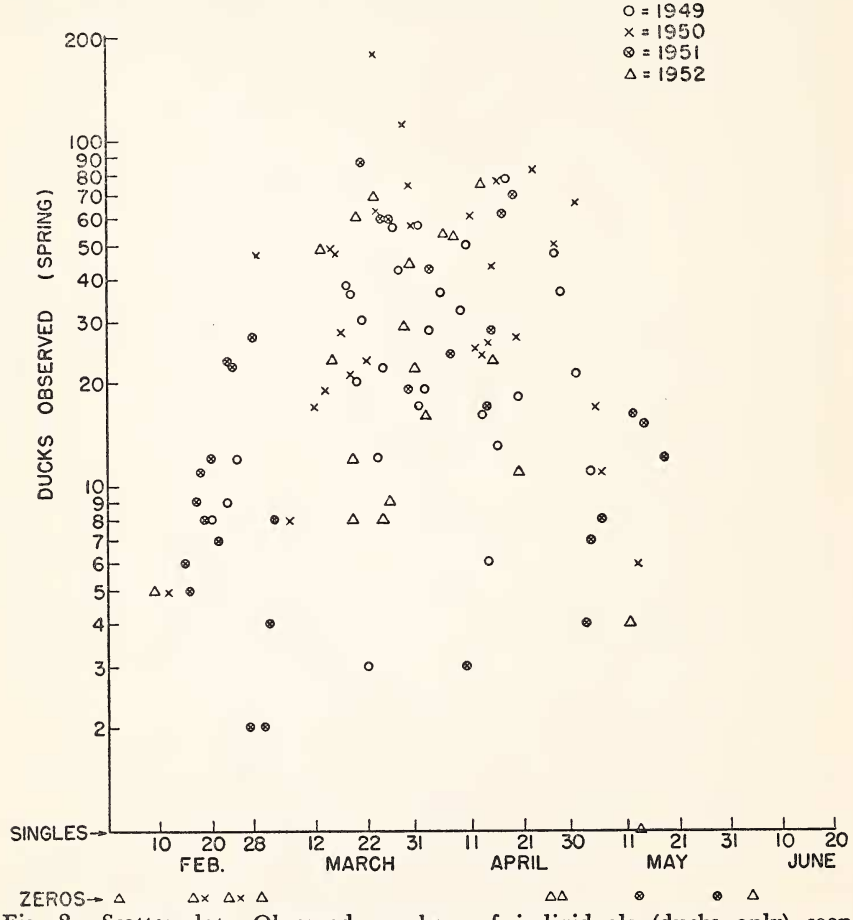

Fig. 2. Scatter-plot. Observed numbers of individuals (ducks only) seen on spring visits in the years 1949-1952. The vertical scale is logarithmic

not the arithmetical difference between two observations but the *ratio* between the two.

Although there is much scatter, it is immediately obvious that a first approximation to the facts would be a parabolic curve with its axis early in April and its vertex at a few dozen ducks. Such a curve is logical. When restored to arithmetical (instead of logarithmic) ordinates, it will be a Gaussian "normal" curve. Accordingly, it seemed worth while to fit a parabola to the logarithmic plotting, by the method of least squares. In order to reduce the amount of work, all the observations over a 10-day period (the same 10-day period in each of the four years) were averaged, as in Fig. 3, and it is to these points that the parabola, the transformed Gaussian curve, is fitted. Fig. 4 shows the same data as Fig. 3 with the logarithmic scale eliminated and the ordinates plotted arithmetically. The curve now takes the "normal" or Gaussian "bell-shaped" form.

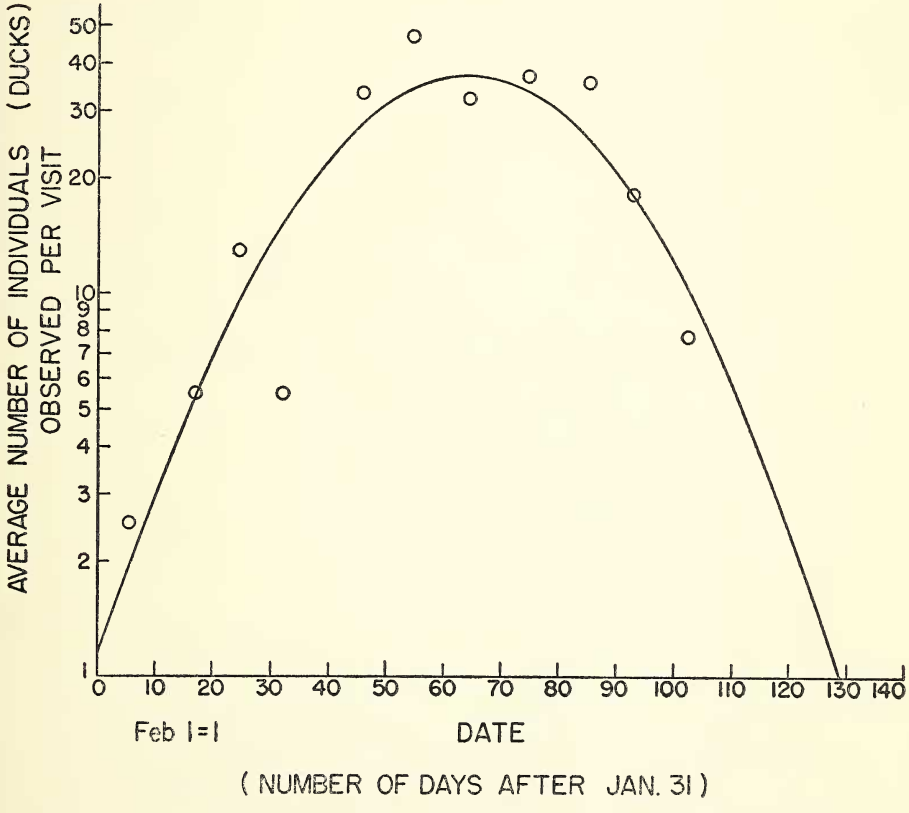

Fig. 3. Averages of 10-day intervals, for the same data as in Fig. 2, plotted on the same logarithmic scale

The tentative inference from this is that the overhead traffic in the skyways pool is heaviest on April 6 (a date close to the week-end usually chosen by the Audubon Society of Western Pennsylvania to visit Oneida), but that there is a wide spread in the dates at which a fair number of ducks may be seen. In slightly more mathematical language the standard deviation, σ, is 24.1 days, so that one-quarter of the ducks will have passed through 16 days ahead of April 6, and one-quarter still remain to pass through 16 days after April 6.

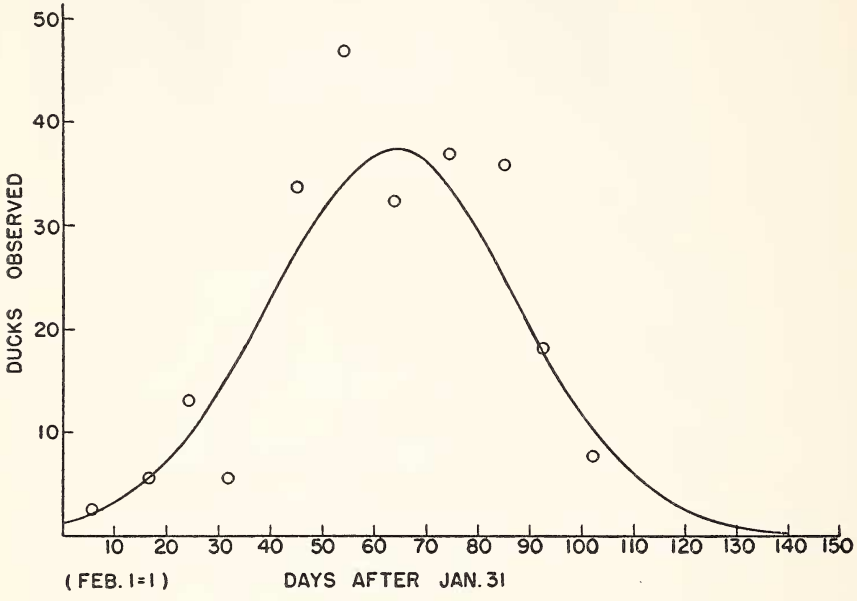

Fig. 4. Data of Fig. 3 with logarithmic ordinates eliminated

Now although this is perhaps as logical and satisfactory a "graduation" as can be made of the data relating to total individuals, the picture is not at this stage complete, or might be regarded as of less than average interest, because the scaup duck (presumably in nearly all cases the Lesser Scaup) forms such a large proportion of the total population.

In Fig. 5, we give the scatter-plot for number of *species* observed instead of number of individuals. Here we have used arithmetical ordinates, but in Fig. 6 we have graduated the logarithms, and then converted back to arithmetical ordinates in Fig. 7. The data can be fitted reasonably well to a Gaussian normal curve, as before, and its crest is at a not very different date. Since the number of species of ducks proper observable on any one day is likely to be low, we have here taken waterfowl in a somewhat broader sense, including geese, swans, grebes, loons, coots, gulls, terns, herons, and egrets, but excluding shore birds, ospreys, eagles, and kingfishers. The kingfishers are properly excluded, being summer residents. The exclusion of the

others is somewhat arbitrary, since only the Spotted Sandpiper and Killdeer are summer residents. The exclusion of ospreys and eagles makes little difference, since there is only one species of each, never more than one individual, and rarely that. The shore birds also are very few in species and individuals in the spring, because the lake is full and there are no mud-flats.

There is some slight possibility that the curve is bimodal, involving a preliminary small migration in February (as the ice begins to melt, on a temporary basis, at the north or inlet end, which frequently freezes), and then the main migration starting in early March. It is only the second

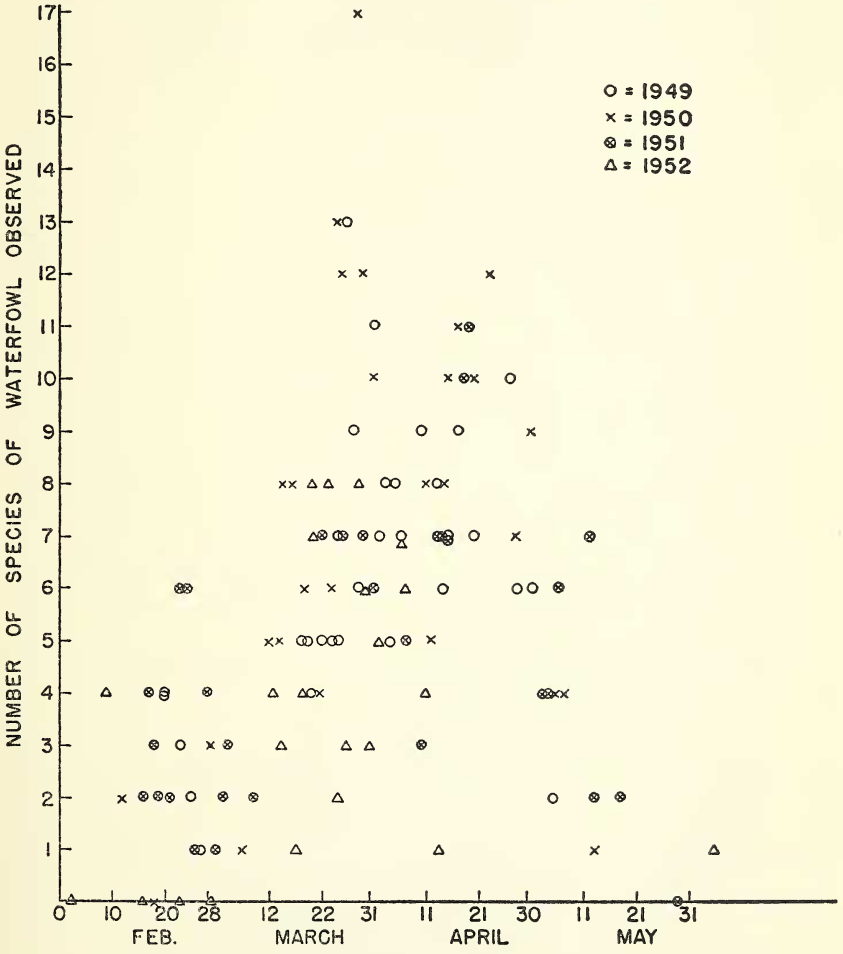

Fig. 5. Scatter-plot of observed numbers of species of waterfowl in spring, 1949-1952. Arithmetical ordinates

phase that contains scaup ducks. The earlier one contains a substantial number of species, such as the Golden-eye (the "ice-duck" of the Norwegians), Red-breasted Merganser, American Merganser, Ring-necked Duck, Redhead, Canvas-back, Mallard, Black Duck, and Gadwall, as well as a gull or two. The Baldpate, though it has been recorded more than once in February on the Laboratory grounds, has not been recorded at Oneida till March 1, which is also the first date at Oneida for scaup (two individuals), but there is no other Oneida date for scaup earlier than March 11.

Since observations are relatively few early in March, because I am regularly out of town for some days, the bimodal aspect should not be emphasized.

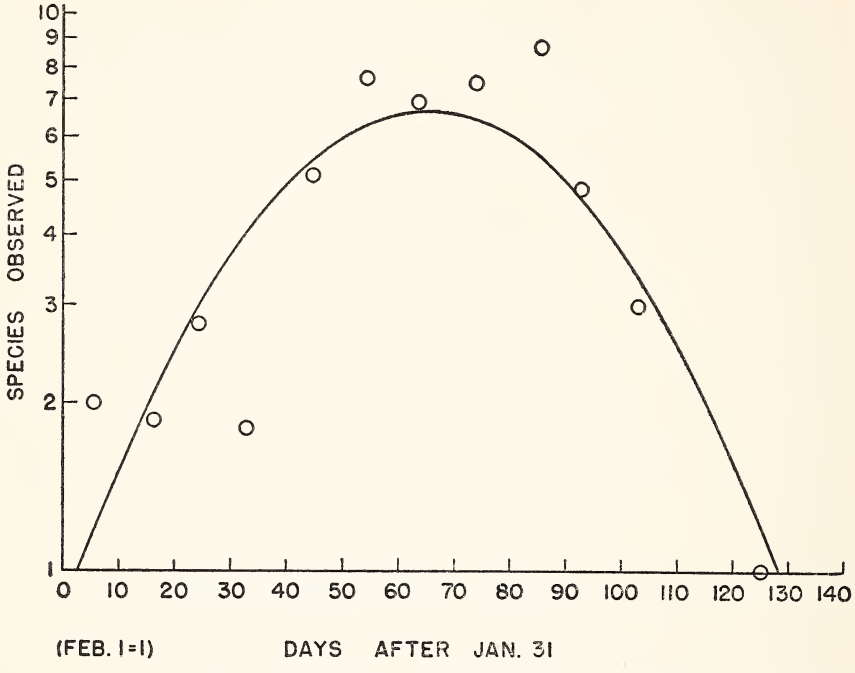

Fig. 6. Observations of Fig. 5 reduced to 10-day averages (circles). Logarithmic ordinates

Spring migration of the scaup. Fig. 8 shows a scatter-plot of the four-year observations on this species, believed to be mostly Lesser Scaup, though, since both species (greater and lesser) have been seen at the Laboratory grounds, it is most likely that both have been seen at Oneida. Fig. 9 reduces the observations to 10-day intervals and fits a parabola to them, while Fig. 10 removes the logarithmic feature. The vertex seems to be at about April 13, which is later than for ducks in their entirety, and agrees with the qualitative observation that the scaup does not appear in February or even early March, is the last bird to linger into late May, and that big flights go through late in the season.

Todd (1940, p. 103) however says, "The Lesser Scaup Duck moves north *very early* in the season," (italics mine). Todd's work is so painstaking and thorough that any phenomena that seem to disagree with his findings should be examined with extreme care to see what the meaning of the discrepancy may be. There is no question here that his findings are right, in the sense that at least *some* scaup do move north very early. Todd's earliest date is February 26, but at Toledo, Ohio, which is farther north than Oneida, it is sometimes much earlier even than this. Thus, on February 7, 1953, in company of Mr. McCormick, I found more than a thousand scaup on Lake Erie near Toledo. They were almost all males. We estimated that males outnumbered females at least twenty to one. I reported the matter to Harold Mayfield, who said that the birds must be spring migrants, since nothing like that number of scaup had been present during the winter.

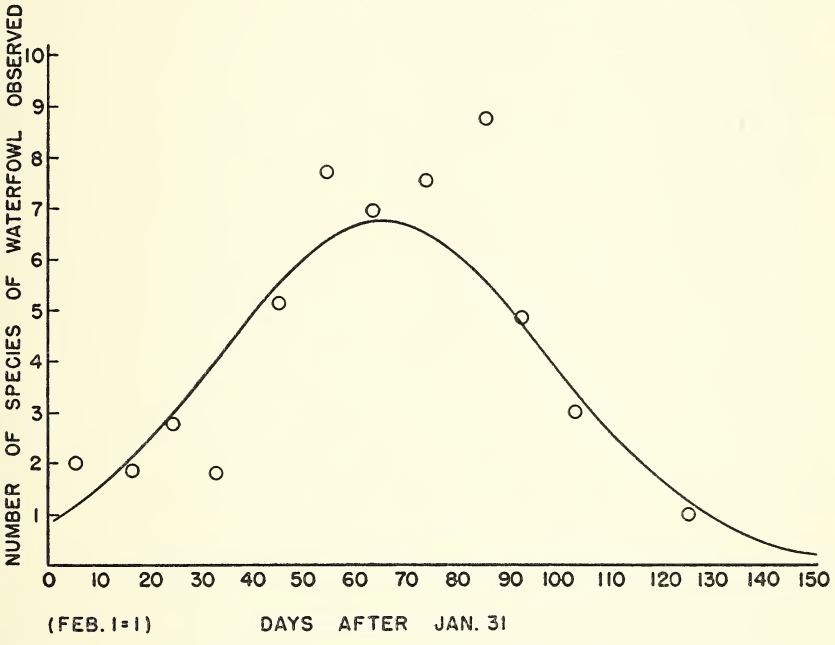

Fig. 7. Observations and curve of Fig. 6 with logarithmic scale eliminated

The situation that develops then is that at Toledo the scaup is a very early spring migrant, whereas at Oneida it is one of the latest. None the less, at both places there is a remarkable predominance of males in the early movements, and perhaps later.

Again, on February 3, 1953, in the company of Dr. E. S. Thomas, of Ohio State Museum, and Dr. Milton Trautman, I found at Buckeye Lake, Ohio, a few scaup, females as well as males.

Concerning this species Trautman (1940, p. 194-195) says, "The first transients (at Buckeye Lake) arrived by March 5," but since, as above mentioned, he was present on February 3, 1953, he agrees that sometimes the first transients are now more than a month earlier.

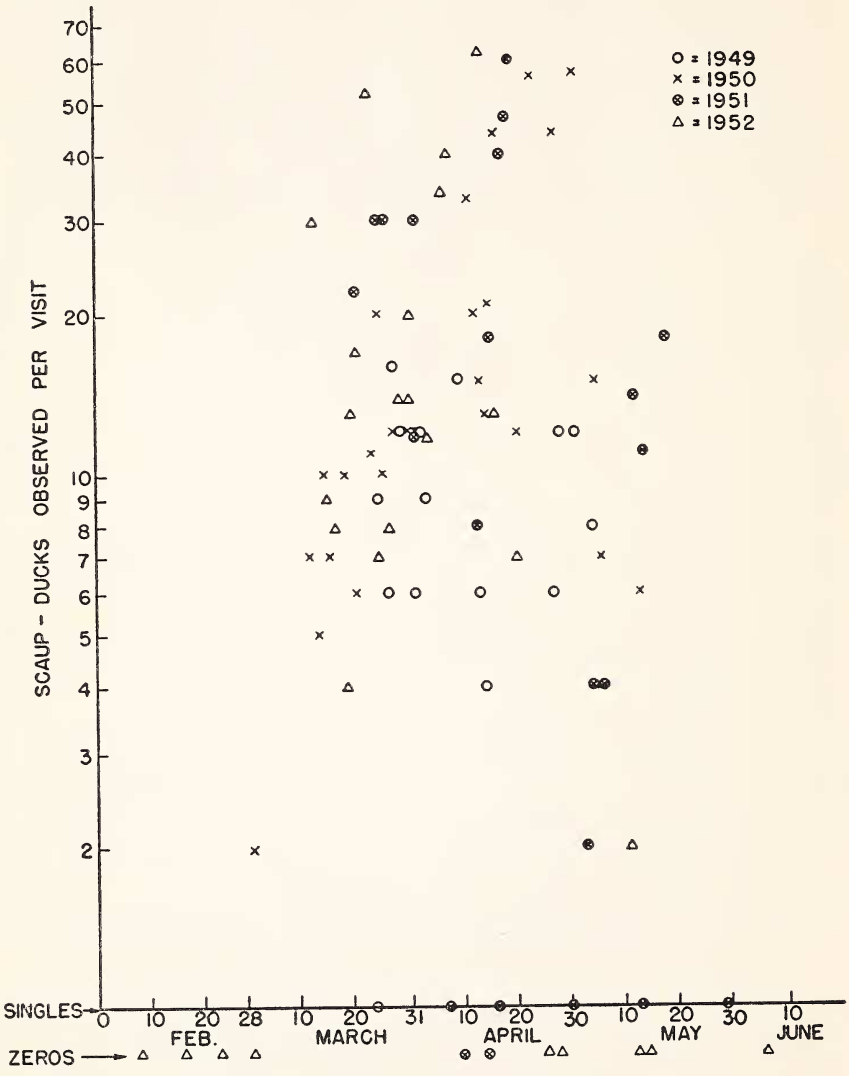

Fig. 8. Scatter-plot. Observed numbers of scaup in spring, 1949-1952. Logarithmic ordinates

All these observations confirm and even emphasize Todd's comment that the scaup is *very early,* in the sense that the first transients of the species are very early, earlier even than he and Trautman have recorded perhaps; but so far as the *average* scaup duck is concerned, the Oneida evidence is conclusive that there, at any rate, the peak migration is later than that of most of the other ducks.

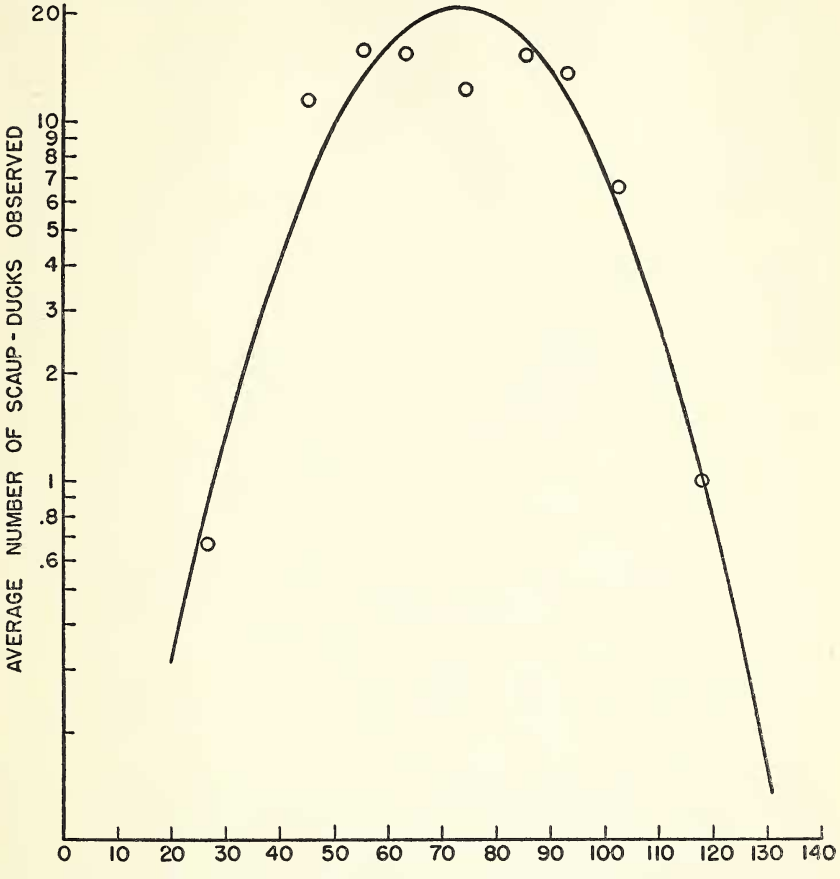

Fig. 9. Observations of Fig. 8 reduced to 10-day intervals and fitted by a parabola

The interpretation, in mathematical terms, of our joint findings would seem to be this: the scaup is by far the commonest of all our ducks, as Table 1 shows. Therefore, although the peak of its migration is late, and the standard deviation of its coming does not appear to be great (18.4 days), its very numbers give us a better chance to see something of the ends of its Gaussian distribution, and in particular to see some scaup very early.

Our own findings, that the Lesser Scaup is on the average a late, not an early, spring migrant agree with those of Kortright (1943, p. 259), "In the spring their return north is . . . tardy," and again, "These Scaups are late breeders, next to the White Winged Scoter probably the latest."

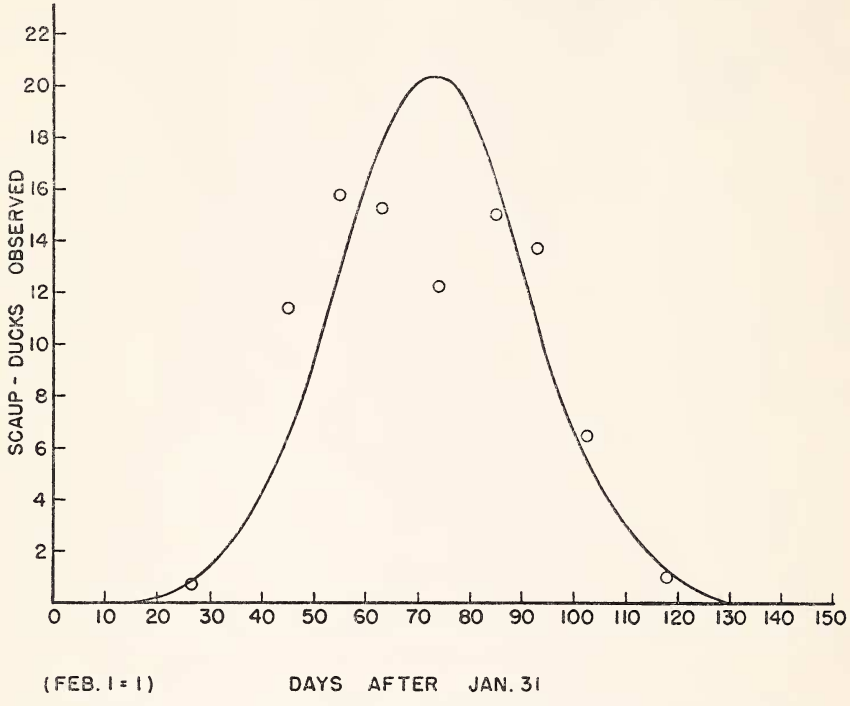

Fig. 10. Data and curve of Fig. 9 with logarithmic scale eliminated

The fall migration. Ducks. As already mentioned, Oneida attracts fewer ducks and waterfowl in the fall, and more shore birds. The greater attraction for shore birds is obviously connected with the drop in the water-level, so that there is less acreage of water, and many acres of exposed mud-flat. However, there are probably several other factors as far as the ducks are concerned. Lake Erie, Pymatuning, Conneaut Lake, and Edinboro Lake lie from 60 to 100 miles north. Weary birds from the north would probably rest there, and when taking off again, fresh and revived, would not be attracted to Oneida. Again, in good weather, and the fall is predominantly good weather, the winds are in the west or northwest, and the birds are not likely to run into a "front" that forces them down. Thus the "net" is less efficient in the fall. Obviously the ducks are more numerous, somewhere, in the fall than in the spring, for the spring migration consists of the same birds that came south in the fall, minus those that perished over the winter.

It is possible that the fowl use a somewhat different flyway in fall from that which they use in spring, and the fall one may not pass over Oneida; but this is conjecture and seems much less likely than that the dam is less attractive and efficient in the fall.

Years ago I thought that the relative scarcity of ducks on Oneida in the fall, as compared with the spring, might be because there is a hunting season in the fall. Later I came to think that it might be due to the normally much shrunken condition of the autumn lake. It does not seem likely that the latter hypothesis can be right, because F. D. Walker, of Edinboro, Pa., reports that on Edinboro Lake, some 70 or 80 miles north of Oneida, the ducks in spring are three or four times as numerous as in fall, though the lake is full of water at both seasons. It is a lake comparable in length with Oneida, but considerably wider. Nor does it appear likely that hunting has much to do with it, because the hunting season does not open till the crest of the migration has passed. The birds can hardly be supposed to be avoiding the hunting season.

We seem therefore to be left with some such hypothesis as the one that assumes that these lakes are not so favorably located for the fall migration as for the spring one, possibly due to their proximity to Lake Erie, as previously mentioned, or else that, on the spring migration there is some barrier, climatic or constitutional, to the birds' pressing on to the north, while there is no such barrier to their southward movement in the autumn.

Fig. 11 shows the scatter-plot. Fig. 12 graduates it to a parabola, and Fig. 13 eliminates the logarithmic ordinates.

The average number of birds seen per visit was approximately 8, compared with 28 in spring. Once more, the figure refers to ducks only, and excludes swans, geese, and other water-birds.

Sex ratio of the spring migrants. In my notes for February 20, 1951, is a comment to the effect that Mallards seem to come north in mated pairs, but most of the other species are predominantly unmated, and that the great majority of the birds are males. I have found occasional flocks of females, but the general picture seems to be that males are far more numerous. Whether this means that males really do outnumber females by a huge margin, or whether it means that males use Oneida in spring much more than females do, is not clear from these observations alone. At one time I assumed that the males went north to establish territories, and, running into adverse climatic conditions by starting too early, were forced to spend a little time at Oneida. The females, presumably following later, would not meet with the same obstacles and would pass right over. Possibly a count of sexes at various times on the wintering grounds in Florida or elsewhere might throw some light on the subject.

Davis (1952), quoting Hochbaum (1944), says that ducks form mated pairs in the south before leaving their wintering grounds. This seems to be true of Mallards and Black Duck, but the diving ducks at Oneida in spring do not give that impression. Some diving ducks do appear in pairs, it is true, but the big flocks seem to have an overwhelming preponderance of males. The sex composition of the flocks was not always recorded, but very often it was, and a few examples are given below:

1949. Spring. *Red-breasted Merganser.* March 14; 5, all males. April 10; 7, 6 males and 1 female. April 27; 13, all females. April 28; 9, all females.

1949. Spring. *Bufflehead.* March 27; 6, all males. April 5; 12, 6 males and 6 females.

1950. Spring. *Redhead.* March 1; 44, 34 males and 10 females. March 12; 4, 3 males and 1 female. March 14; 10, "mostly males." March 15; 7, 6

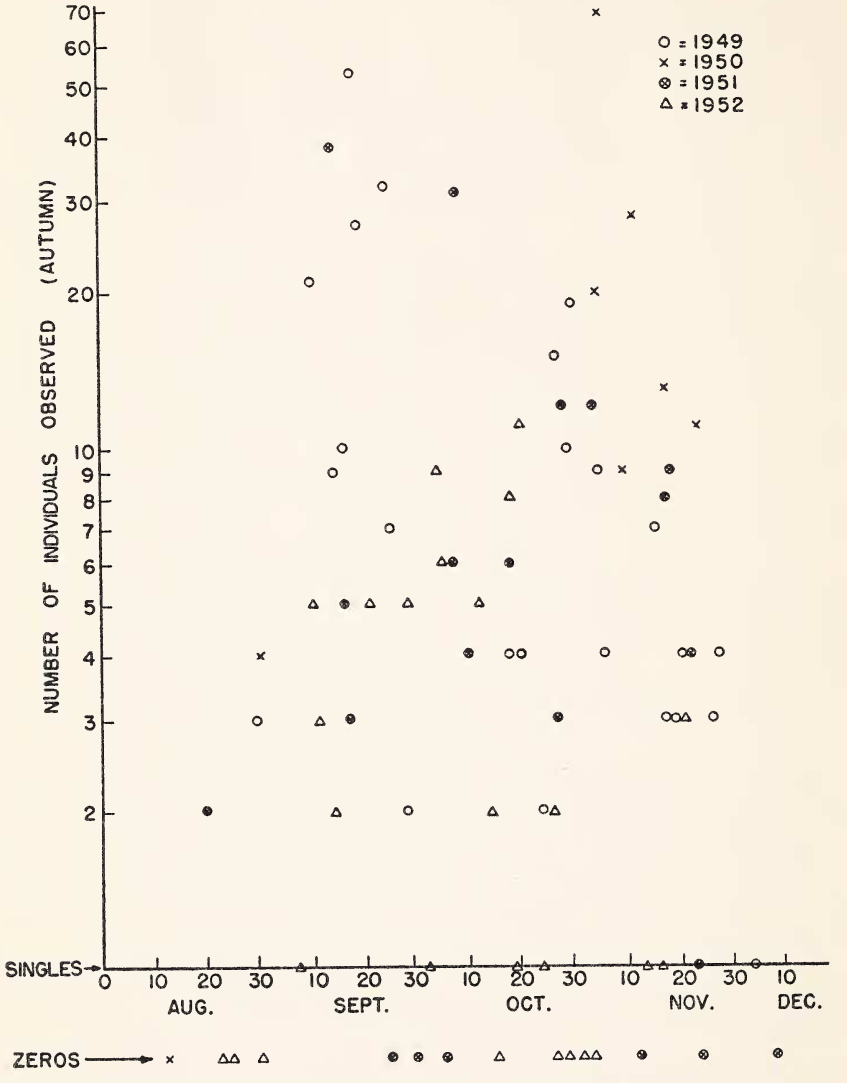

Fig. 11. Scatter-plot. Observed numbers of individuals (ducks only) seen on autumn visits in the years 1949-1952. Logarithmic ordinates

males and 1 female. March 16; 8, 6 males and 2 females. March 19; 4, all males.

1950. Spring. *Scaup.* March 12; 7, 6 males and 1 female. March 14; 5, all males. March 15; 10, all males. March 16; 7, all males. March 19; 10, all males. March 24; 11, 10 males and 1 female. March 29; 12, 8 males and 4 females. April 11; 33, "mixed sexes." April 13; "18 scaup and Ring-necked Ducks, mostly males".

1951. Spring. *Golden-eye.* Males and females often appeared separately; when together, the males outnumbered the females. The species was present intermittently from February 16 to April 13; males from February 16

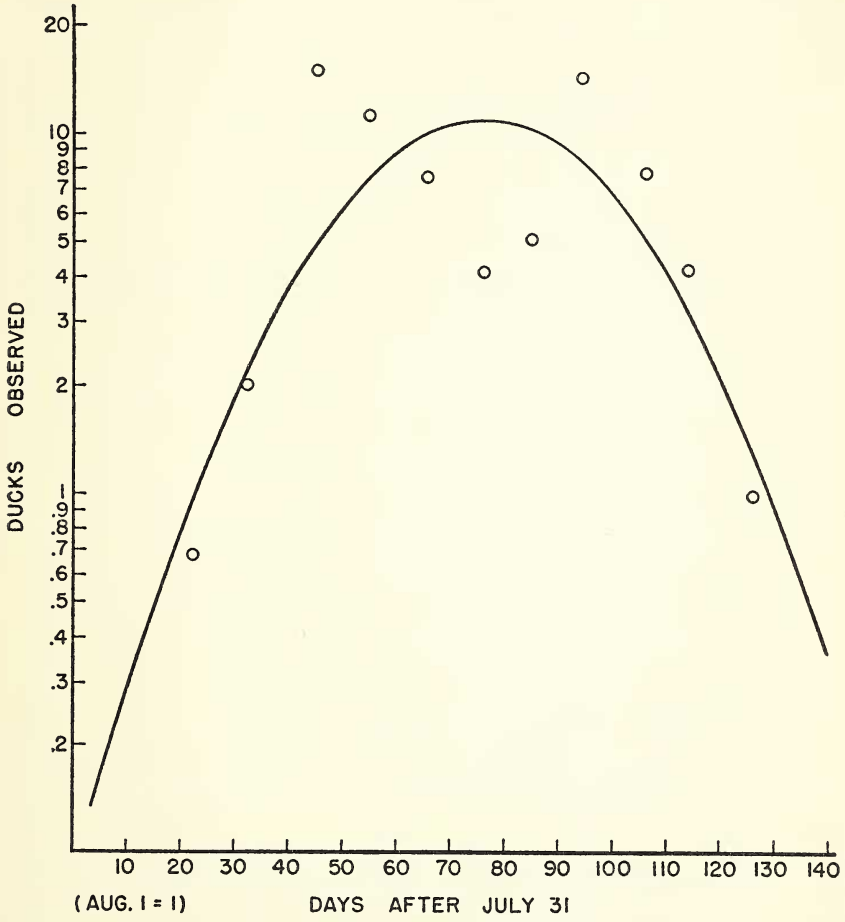

Fig. 12. Observations of Fig. 8 reduced to 10-day intervals and graduated by a parabola

to March 4, females from February 17 to April 13. Maximum number of females on any one day, 2; males, 6. Total observed males 37; females, 12.

1952. Spring. *Scaup.* March 13; 46 Ring-necked and scaup duck, 40 males and 6 females. March 21; scaup, 17, 16 males and 1 female. March 25; 7, 3 males and 4 females. March 29; 14, 7 males and 7 females. March 30; 14, "mostly males." March 31; 20, 18 males and 2 females. April 6; 34, "mixed sexes." April 13; 62, "mostly males, but some females".

1952. Spring. *Bufflehead.* March 30; 23, 18 males and 5 females.

1950. All species of genus *Aythya.* March 1 to April 13. Approximately 175 males and 50 females. One-third of the females did not appear till April, but only about one-fifth of the males appeared in that month.

There is a definite statistical pattern here, but its biological meaning is obscure.

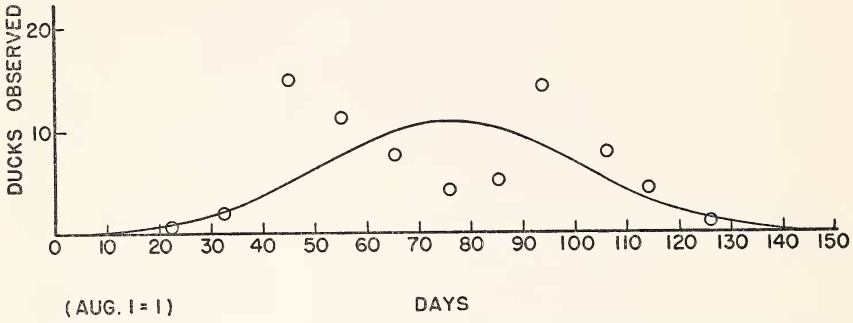

Fig. 13. Data and curve of Fig. 8 with logarithmic scale eliminated

Trautman (1940, p. 194-195) has noticed the early preponderance of male scaup at Buckeye Lake, Ohio. He says, "The March flocks contained more well-marked males than females or males in changing plumage; early April flocks were rather evenly divided between these classes; and in late April and thereafter the flocks contained many more females and immature males than well-marked males". These statements are undoubtedly true, but they leave the impression that, averaged over the whole spring migration, one sees females about as often as males. This is not the case. Both Dr. Trautman and Dr. E. S. Thomas (1953), who also is very familiar with Buckeye Lake and was frequently with Dr. Trautman there, agree that, averaged over the season, observations of males outnumber those of females at least four to one; and further, they are inclined to put upon it the same interpretation as mine—that the males, coming early, dawdle by the way and spend four times as long in going through as the females do, when the latter come later and keep going.

Todd (1904, p. 520, and 1940, p. 103) has no very definite observations on this sex ratio question, nor does Sutton (1928, p. 74). The phenomenon is none the less a very striking one.

Shore birds. The fall of 1949 was a good time for shore birds at Oneida, and led me to suppose that many species might be seen by careful watching

in subsequent years. In 1950, however, the summer and fall were relatively wet, and the dam was not drawn down enough to attract shore birds. In 1951 it was low, and in 1952 very low, but the count of shore birds, though higher than in 1950 (when there were none) did not reach the 1949 level by any means.

Shore birds are not so easily counted as ducks, and diving ducks, when diving, not so easily as surface-feeding ducks or sleeping ducks. So long as the numbers are not large, however, or the birds too active, two or more observers can always agree about ducks. A good test was provided by the swans of April 1, 1952. Mr. McCormick counted them and I counted them. His count was 131, and mine, 133, on a single trial, and considering that the birds were moving about somewhat actively, this was satisfactory, and we thought we could compromise amicably on 132. But the same number of shore birds, unless sleeping, would be very hard to estimate with a probable error of less than 10 per cent. Killdeers are the birds that appear in greatest numbers on the mud-flats, and they are continually flying about, so that it is impossible to keep accurate track of them. In consequence, in the present paper, no quantitative work is reported on shore birds.

Species-composition of the spring migrants, excluding gulls, terns, and shore birds. The faunal assemblage as seen at Oneida is tabulated below. It may not agree exactly with some of the other tabulations, since I fear I have not been absolutely consistent throughout this paper in admitting, or excluding, observations by Howard H. Elliott, and may have made other minor adjustments in one section or other of the paper. There is no reason to suspect, however, that such discrepancies affect the validity of any conclusions that are here drawn. In the present section, *only birds seen at Oneida* are recorded, and Boydstown, Thorn, and the Laboratory grounds are rigorously excluded. Some of the observations are by Mr. Elliott, but the great majority are my own. The report covers the bird-days for each species as accumulated over the four-year period, on observations of the *spring migration only.*

TABLE 1. OBSERVATIONS OF SPRING MIGRANTS

Common Loon	109	Green-winged Teal	3
Horned Grebe	68	Blue-winged Teal	100
Pied-billed Grebe	111	Shoveller	2
Double-crested Cormorant	1	Wood Duck	12
Great Blue Heron	15	Redhead	195
American Egret	4	Canvas-back	46
American Bittern	2	Ring-necked Duck	170
Least Bittern	1	Scaup	1253
Coot	45	American Golden-eye	95
Whistling Swan	167	Buffle-head	103
Canada Goose	174	Old-squaw	11
Mallard	47	White-winged Scoter	3
Black Duck	240	Ruddy Duck	97
Gadwall	24	Hooded Merganser	78
Baldpate	403	American Merganser	18
Pintail	131	Red-breasted Merganser	178

A few interesting points emerge from this table. Although the table accounts for only 3209 ducks (excluding geese and swans), the proportion of scaup, 1253, is still just about the same percentage as in previous tables, viz., 39.1 per cent.

Black ducks outnumber Mallards five to one. Since the Black Duck is primarily a bird of the eastern seaboard, and the Mallard of the interior, Oneida seems here to be definitely in the Atlantic flyway where these two species are concerned. From observations made in the company of Dr. E. S. Thomas near Columbus, Ohio, I get the impression that there, only 200 miles west of us, Black Ducks and Mallards are about equal in numbers, and Dr. Thomas believes that the immigration of the Black Ducks is a recent phenomenon.

The Red-breasted Merganser is ten times as common as the American Merganser (Goosander), and twice as common as the Hooded Merganser.

The Ring-necked Duck and the Redhead are about equally common (170 and 195 respectively), and the Ruddy Duck is about as common as the Buffle-head (97 and 103), or as the Golden-eye (95).

Although the Black Duck is so much commoner than the Mallard, it is not the commonest of the pond ducks. That distinction belongs to the Baldpate (403 vs. 240), but this is due to the Baldpate often appearing in very large flocks, occasionally of 60 or 80 individuals. The Black Duck is seen more often, but the largest flocks observed were of 16 and 20 individuals. Baldpates were seen (in spring) on only 34 occasions, while Black Ducks were observed 57 times.

With those species that move in large flocks, a single observation, made or missed, can make a vast difference in the count. Thus of the 167 swan-days reported, 157 are due to the single large flock of 132 birds forced down by a line-squall, as previously mentioned. Half of the goose-days are due to a single flock of 85 birds observed by Howard Elliott one evening.

Superficially, there is a great difference from year to year, even with those species where the total count is not due primarily to a few large flocks. Thus the annual spring count for scaup goes: 140, 466, 353, 294; but for Ring-necked Ducks the progression is quite different, viz. 81, 52, 16, 21.

The count for Black Duck was 77, 99, 57, 7; and for Mallards, 12, 19, 16, 0.

These differences do not seem to be due to the relative frequency of my visits to Oneida, and it is not clear that they are due to timing, though both may play some part.

Black Duck seen per visit (counting only those visits on which at least one was seen) come out as follows: 1949, 4.5; 1950, 4.7; 1951, 3.8; 1952, 1.7. But it is possible that the differences are not significant, and it seems improbable, in view of the tendency of this species to move at times in pairs and at others in flocks, that any simple statistical treatment would help.

The Common Loon. It is likely that, even when a species is not observed on more than a few dozen occasions, or in numbers exceeding

a few score, a detailed count on each occasion may permit the testing of various hypotheses or current notions on how the bird behaves.

This has been done in some detail in a separate paper (Preston, 1956)*, and it is therefore unnecessary to do more than summarize it here.

The Common Loon is an extremely late migrant in spring, lagging far behind the ducks as a whole and even behind the Lesser Scaup. The peak of its migration is at April 22. Further, this species migrates much more nearly simultaneously than ducks as a whole, or even than the scaup. The standard deviation of the timing is 11.6 days for the Loon, 18.4 for the scaup.

This suggests that the Loon does not start north till its breeding grounds are ready for it; and when it starts, it goes right through. Thus the Loon is probably commoner in the skyways than its numbers, compared with the scaup, would suggest. With a cruising speed, unhurried, in excess of sixty miles an hour (Bent, 1946; Preston, 1951), it does not need to dally at Oneida. We see few of them unless they are forced down by fog or rain.

Normally the Loons we see at Oneida are not organic flocks, but random assemblages. At the peak of the season the most likely number to be seen is three, and they are usually well separated and paying no attention to each other. There is no evidence in the field that any of them are mated pairs, and a mathematical analysis of the subject suggests that they are moving as individuals, not as pairs.

Table 2 gives a conspectus of the migrant water-birds seen, in spring and fall (S and F) for the four years 1949 to 1952 inclusive. It is quantitative only as to species. Some species may be represented by only a single individual, as with the Northern Phalarope, and others by more than a hundred, as with the Whistling Swan on April 1, 1949.

A few comments on Table 2 may be useful. First of all, some species are conspicuous by their absence, and others have not shown up to advantage in this four-year period. Thus, I once saw a large flock of Snow Geese on Oneida under the thick mists of early morning, and Mr. Norris has reported a large flock of Snow Geese flying north over the Laboratory grounds. On November 16, 1948, J. M. McCormick found two immature Blue Geese at Boydstown Dam, immediately above Oneida, and it is reasonable to suppose this species occasionally visits Oneida. Only one, slightly uncertain, record is given for Oneida itself, the bird disappearing before I could be absolutely sure of it. Again, only one record is given for the Caspian Tern, in the spring of 1950, but another individual (or the same one) spent some time there in the fall of 1948 (September). The Dunlin, or Red-backed Sandpiper, was present in the fall of 1948, too.

The Shoveller is recorded on Oneida only in 1950 (spring); but it occurred on other, smaller, local ponds once or twice in this four-year period, and I saw it in greater numbers on Oneida a few years earlier. The Canada Goose probably occurs every spring and most falls, but it is somewhat easily scared out and probably remains only from dusk to dawn. On one

*Charles S. Pearce, Manager of the American Ceramic Society, of Columbus, Ohio, says that paper should be entitled "The marital status of migrating loons".

TABLE 2. MIGRANT WATER BIRDS

Species	1949 S	1949 F	1950 S	1950 F	1951 S	1951 F	1952 S	1952 F
Common Loon	x	x	x	x	x	x	x	x
Red-throated Loon		x						
Horned Grebe	x		x	x		x	x	x
Pied-billed Grebe	x	x	x	x	x	x	x	x
Double-crested Cormorant			x					
Great Blue Heron	x	x	x		x	x	x	x
American Egret					x			
Little Blue Heron		x						
American Bittern			x					
Whistling Swan	x		x		x	x		
Canada Goose			x		x		x	x
Blue Goose		x						
Mallard	x	x	x	x	x	x		x
Black Duck	x	x	x	x	x	x	x	x
Gadwall	x				x		x	x
Baldpate	x	x	x		x	x	x	
Pintail	x	x	x			x	x	x
Green-winged Teal		x			x	x		x
Blue-winged Teal	x	x	x		x	x	x	x
Shoveller			x					
Wood Duck			x		x			x
Redhead	x		x		x	x	x	
Ring-necked Duck	x		x	x	x	x	x	x
Canvas-back			x		x		x	
Scaup	x		x	x	x	x	x	x
American Golden-eye	x		x		x	x	x	x
Buffle-head	x	x	x	x	x	x	x	
Old-squaw	x		x		x		x	
White-winged Scoter					x			
Ruddy Duck	x	x	x	x	x	x	x	x
Hooded Merganser	x	x	x		x	x	x	x
American Merganser (Goosander)			x		x			
Red-breasted Merganser	x	x	x		x	x	x	
American Coot	x	x	x	x	x	x	x	x
Semipalmated Plover		x						x
Killdeer		x	x	x	x	x		x
Wilson's Snipe								x
Solitary Sandpiper					x			x
Greater Yellow-legs	x	x	x		x	x		x
Lesser Yellow-legs		x	x		x	x		x
Pectoral Sandpiper		x						x
White-rumped Sandpiper		x						
Baird's Sandpiper		x						
Least Sandpiper		x			x			x
Red-backed Sandpiper (Dunlin)		x				x		
Stilt Sandpiper		x						
Semipalmated Sandpiper		x						x
Northern Phalarope		x						x
Herring Gull	x	x			x			
Ring-billed Gull			x			x		
Bonaparte's Gull	x		x		x		x	
Common Tern		x						
Caspian Tern			x					
Black Tern		x			x			
Forster's Tern		x						

day in the quadrennium, Howard Elliott saw a large flock come in at dusk half an hour after I had left Oneida. In 1952 a single individual came in to the Laboratory grounds at 4:30 P.M. and stayed into the night but was gone early next morning. The Black-crowned Night Heron presumably occurs regularly at Oneida, but is abroad only at night, when I am not there. I have seen the species at Thorn Dam at dusk, and at the Laboratory grounds for weeks on end.

Forster's Tern is a new species for western Pennsylvania, and Mr. Todd, properly, rejects the observation. I did not at the time realize that it had never been seen here before, or I could perfectly well have collected it, but since Mr. McCormick and myself are both completely satisfied, I can not very well reject my own records. The bird may be seen in some numbers at Toledo, Ohio. The Black Tern is probably more frequent than the records indicate. It has several times been seen on the Laboratory grounds and at even smaller ponds.

Bonaparte's Gull seems to be regular in spring, but absent in the fall. The other gulls and terns are seen at both seasons. The Canvas-back and Old-squaw also seem to be spring migrants, while the other ducks, geese, and swans are likely to show up in the fall also, though not in such numbers or with equal certainty as in the spring.

I have expected the Gray (Black-bellied) Plover and the Golden Plover to show up in the fall on the mud-flats, some of which are wet and some fairly dry, but I have never seen either species, either in the quadrennium or earlier. They occur in some numbers near Sandusky, and near Columbus, and in great numbers on the New Jersey marshes, so presumably one of these days a few strays will reach Oneida. At present I am inclined to suspect that the skyway over Butler County does not normally contain this species at all, but there may be other explanations. Near Toledo and Sandusky the birds are remarkably local, though very plentiful where present at all.*

Of the other birds that might be expected to be attracted to Oneida, some mention must be made. The Bald Eagle is occasionally there but only as a bird of passage and very briefly. I have seen it attacked by crows. The Osprey is much more regular. In fact, in April it is present all the way from Oneida northeast to New York state. Apparently it catches fish in the riffles of the streams, from the Allegheny River at the junction of the Clarion over to the Susquehanna watershed. It regularly appears at the Laboratory grounds, and catches fish in the Carrie Dam. Occasionally it is present as late as June.

The Belted Kingfisher is present about nine months of the year, and nests (or has nested) below the Oneida spillway. The Little Green Heron is present on all the streams, probably, of the district, and regularly nests at the Laboratory grounds. It is, therefore, omitted from the tabulation. The Spotted Sandpiper nests at Oneida, as well as at the Frith (the inclosed grounds of the Preston Laboratories, three miles due west of the center of Butler, Pa.), but at the former place it appears to me less common than it was years ago. This may be because of the great increase in the

*A single individual of the Black-bellied species finally put in an appearance on September 29, 1953.

number of fishermen that crowd the banks. The Solitary Sandpiper is more common at the Laboratory than at Oneida, perhaps because it is a woodland bird. The American Merganser is occasional at Oneida, but probably regular on our swift-flowing streams, such as the Slippery Rock Creek in the Main Gorge, and the lower Connoquenessing above its junction with the Slippery Rock.

Only one American Egret has been seen at Oneida on migration proper (spring of 1951). Five individuals were present at Oneida from August 8 to September 19, 1948; and, many years earlier, about 1928, I saw about a dozen of them there. An adult bald eagle that flew over the Laboratory grounds at a great height on May 13, 1951, headed due north, was perhaps a Florida eagle headed for the Great Lakes or the Canadian north woods.

I myself have never seen the Florida Gallinule at Oneida, but a bird of the year was caught there by one of my assistants (Sept. 14, 1951). The rarity of the bird in Butler County is a great surprise to me, since in England, under the name of moorhen or water-hen, it is the most widely met of all waterfowl.

Of the passerine birds there is little to say, since few of these are water-birds in any real sense. Oneida is a good place to see the early swallows, and on the cold spring mornings the Carrie Dam in the Frith is a good place, too. The water supplies the few insects that are abroad when the ground is chilled to the freezing point but the water is open. The American Pipit is a tundra bird. In the fall I have seen it in hundreds among the dead tree stumps of the mud-flats of Mosquito Creek Dam, just over the border in Ohio. The only place I myself have seen it in Butler County is at Oneida Dam, on two occasions, once in some numbers. But Howard Elliott and Earl Schriver have reported flocks of the species in other parts of the County, so neither water nor mud-flats are essential. Crows are rather plentiful around Oneida, and in the fall vast flocks of Starlings, with some Red-wings and perhaps other species, roost in the woods adjoining the lake, but this has no obvious connection with the presence of the lake itself: it is not the only Starling roost of the County, nor a principal Crow roost.

The Rusty Blackbird occasionally appears at the Laboratory, but I have not yet recorded it from Oneida, where it might be expected.

Rarities, unusual dates, etc. Birds not often seen in western Pennsylvania, at any rate not often seen south of the lakes area in the extreme northwest corner, or reported by Todd (1940) to be infrequently observed there, are as follows:

The Red-throated Loon (November 15-17, 1949) has been reported very seldom. One of the earlier records, however, was from Oneida.

The Double-crested Cormorant (April 13, 1950) is quite uncommon, though one made itself conspicuous along the Allegheny River a few years ago.

The Whistling Swan is common enough, and I mention it here because its flyway appears to be narrow. The bird is common near Youngstown and on Lake Erie near Toledo, but unusual near Columbus, Ohio. It would seem that Columbus lies southwest of the flyway.

The Gadwall is fairly regular in its appearance. Todd seems to have thought it rather uncommon short of the Lakes.

Todd says the Long-tailed Duck, or Old-squaw, used to be common on Lake Erie but has been all but exterminated in the interests of the fisheries. None the less it has visited Oneida every spring in the four years under review, though only in small numbers.

The White-winged Scoter is reputed to be regular at Youngstown, but has been reported only twice at Oneida, both times in the spring of 1951.

The Northern Phalarope has appeared twice, and the 1952 individual stayed for about a week. The bird is regularly seen near Toledo, but not in any numbers; it is rare at Buckeye Lake, Ohio. It may be less rare overhead in Butler County than at present appears.

The Caspian Tern and Forster's Tern have already been commented on. The Caspian Tern's date was very early (April 11, 1950). On the previous day, driving home from Toledo, I had seen a couple of these birds at a small pond near Fitchville, Ohio. A very strong west wind was blowing, and I thought it possible some migrants might be blown into Pennsylvania. I suggested to Mr. McCormick that we go to Oneida and find a Caspian Tern. We went, and there was the bird.

The Little Blue Heron was, of course, an immature in white plumage. The same species, in the same plumage, has been seen on the Laboratory grounds, but only once.

The White-rumped Sandpiper is represented by a single individual at Oneida, but again, a single individual was also seen in an earlier year, at the Laboratory.

The Greater Yellow-legs stays somewhat later than Todd reports. In 1949, one individual was present on November 20, an all-time record according to Todd, but 20 were present on November 10, and eight on November 15.

Three Dunlins (Red-backed Sandpipers) were present on November 20, 1949, again an all-time record according to Todd, but one was present on November 24, Thanksgiving Day. The Dunlin is a very late migrant at Toledo, and I think Todd underestimated its tendency to be late on the fall migration. It is the last of the Sandpipers to go through, and it outstays even the Greater Yellow-legs.

Three Killdeers remained till December 4 in 1949, which is quite late with us.

In 1950, a male Hooded Merganser appeared on March 15, which is a comparatively early record.

On April 20, 1950, Mr. McCormick and myself found at Oneida two Greater Yellow-legs with one Lesser Yellow-legs with them, so there was no question of its size. It is a very early record for the latter species.

On February 16, 1951, I observed four male Golden-eyes and one male Canvas-back. The Golden-eyes were early, and the Canvas-back three weeks earlier than anything reported by Todd. The first Ring-necked Duck, a female, appeared on February 23, 1951, which is very early, but a male had been at the Carrie Dam in the Frith since February 19.

Eleven Redheads appeared on February 28, 1951, a day or so earlier than Todd's records, but agreeing closely with our own date of March 1, 1950.

The American Egret of April 15, 1951, was a somewhat unusual observation, spring visitors being rare in Western Pennsylvania.

Pectoral Sandpipers remained at Oneida in 1952 until October 26.

From the detailed records, it is possible to tabulate the first and last (observed) appearance of each species on both spring and fall migrations within the period of four years, but, though such information is not too plentiful, especially as regards *last* appearances, it is doubtful whether it has much utility. At the best, it represents only the tail-ends of more or less Gaussian distributions, which theoretically extend indefinitely to left and right. There is a good deal of evidence in Todd (1940) that many species of ducks will stay on Lake Erie all winter if the winter is exceptionally mild, and a good deal of evidence that many unexpected species will stay and breed at Pymatuning if they find conditions to their liking. Both these facts emphasize the Gaussian character of the time "limits" of the spring and fall migrations. The birds are not set on reaching a particular geographical region, but only on reaching a satisfactory environment. If we could maintain a suitable environment all year round, the birds might cease to migrate at all. This is not altogether surmise. In Britain, with its equable climate, the birds tend to be much less migratory than the conspecific forms of continental Europe. The recent tendency of the European White Stork to nest in South Africa, hitherto merely its wintering grounds, may be an example of the same sort; and the colonization by the Gadwall of the Outer Banks of North Carolina (Pea Island), a thousand miles from its normal prairie summering grounds, indicates the same thing. Migration may be a deeply ingrained instinct, but it seems to be one that is readily dropped as soon as it ceases to be a painful necessity.

UTILITY OF THESE OBSERVATIONS

It is highly probable that if Oneida had been watched continuously over this four-year period, or if it had even been visited every day, a number of additional species would have been seen, and many more significant observations made. As it is, it is probable that no small body of water in our region has been watched equally closely or quantitatively. None the less the period is short and a decade might have been more useful. However, it is probable that the picture is changing. There are vastly more small farm ponds on the Foreland than there were 10 or 20 years ago, and these attract successfully many species, including birds as large as geese, and ducks as relatively uncommon at Oneida as the Shoveller. The number of such ponds will undoubtedly increase, and some may prove superior to Oneida in their seclusion, for Oneida is much disturbed by fishermen and other visitors. When Oneida was new, thirty years or so ago, and less thickly surrounded by anglers throughout most of the year, it is probable that it was more visited by waterfowl and waders (shore birds), especially in the fall. Unfortunately, we have no quantitative records, known to me, of those days.

It seems to me that, if Oneida is watched long enough, everything that has ever been seen at Pymatuning or Erie, in the line of waterfowl, will be seen also at Oneida, and perhaps some species that have not been seen farther north. If this is so, it seems clear that the proposed lake in the valley of Muddy Creek, a few miles to the west, will be a far greater attraction;

for Oneida is a reservoir of drinking water, and is not operated with any eye on the needs of water-birds or the interests of bird lovers or ornithologists. The lake is small, largely free of vegetation, quite free of islands, and, on the face of things, quite unattractive to birds. The proposed lake in Muddy Creek would be many times as large, much more complex in outline, with much more extensive shore-lines, and would intercept a much greater width of flyway.

Whereas no part of Oneida is free from frequent, almost incessant, disturbance from human beings, being completely and closely surrounded by roads and, for most of the year, lined with fishermen, there is a possibility that Muddy Creek can, at least in part, be set aside for wildlife.

At Oneida, while with Mr. McCormick, I have seen a fine antlered deer swimming the lake, and with Mrs. Preston have seen a small herd of deer come down to drink. On Boydstown, beaver could sometimes be seen, and there were until recently several beaver dams upstream from Boydstown. Both species of mammal still occur in Muddy Creek, and there also I have seen the Bald Eagle, the Bittern, Virginia Rail, American Egret, and many other species, though at present there is no expanse of water there. The Marsh Hawk and Red-shouldered Hawk (a swamp species) both nest there, and I have never seen either at Oneida. The Snow Goose has been reported on Muddy Creek, and the Wood Duck and Mallard nest there. Howard Elliott has reported the King Rail nesting at a point not much beyond it, and it would seem that Oneida is only a very tattered net for sampling our skyways.

METHOD OF MAKING COMPUTATIONS

Fig. 2 shows the scatter-plot representing all observations, in four spring-times, of the ducks (excluding geese and swans) observed on the water (not overhead) at Oneida. Such a scatter-plot really contains more information than any other plot that can be devised, but it is too complex to be grasped, and therefore lacks utility. Fig. 11 shows a similar plot for the four autumns, and the same comments apply. It is difficult to make out what is going on.

Accordingly, it is convenient, and useful, for some purposes, to reduce the number of plotted points to a modest number of average points. This has been done by taking 10-day periods, the first being February 1 to 10, inclusive; the second, February 11 to 20, and so on. February 29, 1952, is treated as non-existent, so that March 1 is in every year treated as the 29th day, and March 3 as the first day of the fourth 10-day period. Since observations were not made on every day, it may happen that the average time of observation during the 10 days does not come at the mid-abscissa of that period. Its true position is calculated, and the average of the number of birds seen on each visit constitutes the ordinate for that period. By this means we reduce the plotted points to fifteen or so, and the general shape of a well-fitting curve becomes apparent. (Fig. 3, Fig. 12, etc.) In Fig. 3 the circles are observed points, and the figure suggests that the cut-off in late May is sharper in practice than the computed curve would imply. However, very few visits were made in late May and in June, so the evidence is here incomplete and the computed curve is possibly fairly accurate.

Curves are sometimes fitted on a purely empirical basis. This is not a particularly useful proceeding. The curve that is to be fitted should be logical, not merely a good fit; and of two curves that fit reasonably well, the more logical should be chosen even if it is a slightly poorer fit than the other. The question of logic involves a reference to the physics or biology of the problem and can not be decided solely by statistical ideas.

Thus, the fact that we see a period of maximum abundance of ducks on Oneida near April 6 and again near October 16 does not constitute all that we know about the skyway pool. We know that the birds in spring are headed one way (conventionally "north") and in the fall are headed the opposite way (conventionally "south"). If we take this vector knowledge into account, the question we are really asking is: "How full is the skyway of birds flying north?", or "How much northing is the bird population overhead accomplishing per day?" When expressed in this form, the fall migrants are negative birds, because they are losing "northing." If spring and fall migrants are plotted on the same diagram, the fall migrants should be plotted below the zero line (Fig. 14). We are then led to treat the annual migration as a single event, and should logically "graduate" the curve as a sine curve with a periodicity of 12 months. Such a sine curve has some elements of logic, but the diagram rather discourages it; there is too long a period in the summer, and too long a period in the winter, with zero birds. The sine curve would pass through zero twice a year, but the zeros ought to be short and sharp. The observations themselves accordingly discourage this concept, and this discouragement is fortified by our knowledge of their biology. The birds are not flying north or south to accommodate themselves to the rhythmic movement of the isotherms. They are moving north to breed and moult, a business that takes time, and so there is naturally a complete absence of birds for some time in the summer. In the winter they have to eat, and they will naturally be absent from the frost and freezing, till open water becomes dependable.

On this basis, the birds' biological requirements could be met by the whole of them moving north simultaneously on April 6, and all moving south on October 16. This would be similar to the daily "rat race" that develops in Pittsburgh and other large cities, when all the suburbanites crowd into the down-town districts about 8 A.M. and all rush out at 5 P.M.

The birds also spread or "stagger" their comings and goings over a substantial period. This arrangement presumably arises from the fact that the birds are not exactly synchronized in their internal biological rhythm, and they are not all flying the same routes or starting from the same points. Accordingly, a reasonable assumption would be that enough variable factors are present to induce in the observations the appearance of a "normal," or Gaussian, "curve of errors."

The two migrations, spring and fall, are then to be thought of as separate events, even though one does involve the other. But since the birds do not necessarily follow the same routes coming and going (a matter we know for certain with some other species), and since their behavior, and the composition of the flocks, is most likely quite different at the two seasons, we

are justified in regarding the two events as independent problems, and graduating each one with a single Gaussian curve.

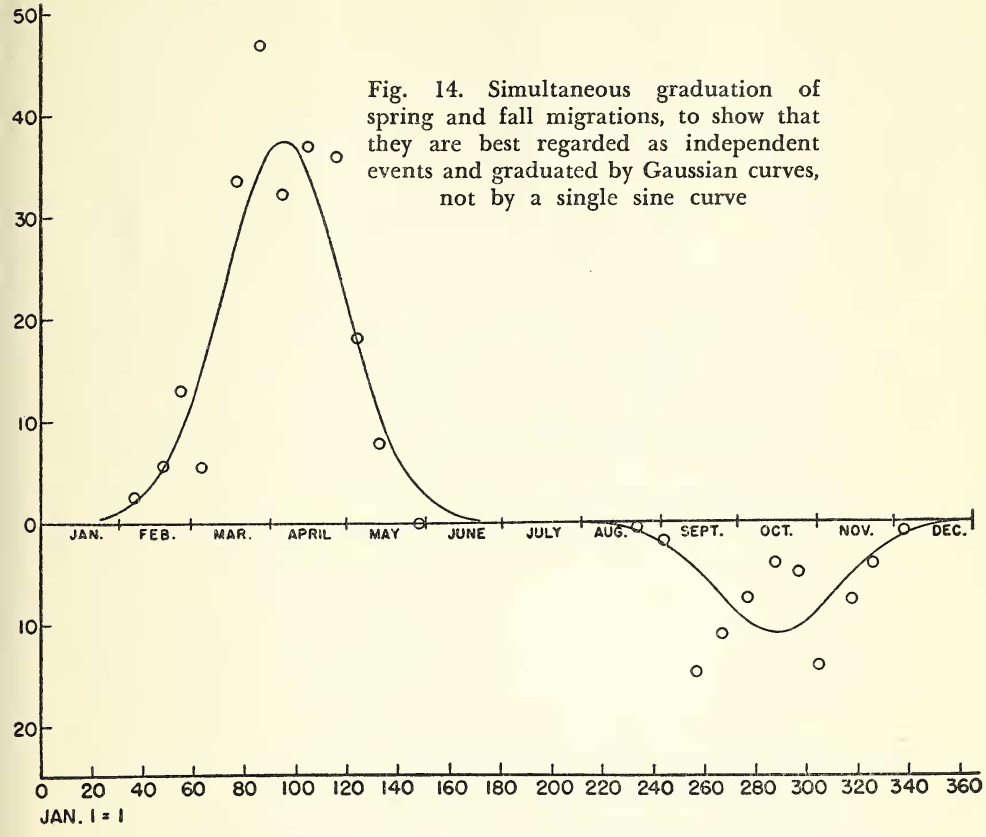

Fig. 14. Simultaneous graduation of spring and fall migrations, to show that they are best regarded as independent events and graduated by Gaussian curves, not by a single sine curve

Consider the spring migration. Let its peak occur at ξ days after January 31. Let the most probable number of birds to be seen on a single visit *at the peak* be η birds. Let us calculate the most probable number (N) of birds to be seen on any other occasion, dated x days from January 31.

We have $N = \eta \cdot e^{-\frac{(x-\xi)^2}{2\sigma^2}}$ .....(1)

where σ is the "standard deviation" in days. (The standard deviation will be discussed below.)

Our problem is to fit the observations with a curve of this type so as to get the best estimates of η, ξ and σ. This can be done in various ways. We have chosen to do it by the simplest and most obvious way, which is good enough in view of the great scatter in the scatter-plots, though it may not be the most accurate method.

Taking logarithms to base e (natural logarithms), equation (1) may be written

$$\log_e N = \log_e \eta - \frac{(x - \xi)^2}{2\sigma^2} \quad \text{.....(2)}$$

or writing y for $\log_e N$ and k (a constant) for $\log_e \eta$ or $\log_e N_{max}$, we have

$$y = k - \frac{1}{2\sigma^2}(x^2 - 2\xi x + \xi^2) \quad \text{.....(3)}$$

This is the equation of an ordinary (quadratic) parabola in y and x. It is a parabola with a vertical axis, and its vertex at $x = \xi$, $y = k$.

Accordingly, we can graduate our observations, if we wish, by plotting the logarithms of the number of birds observed, and fitting a quadratic parabola among the points. This is a reasonable procedure provided that we ignore 10-day periods when we saw no ducks whatever. The logarithm of nothing is minus infinity, and we should have difficulty in accommodating points at minus infinity.* Fortunately, if 10-day periods are taken, the average is not zero till we get outside the real migration period. Our problem then is to fit a simple quadratic parabola

$$y = A + Bx + Cx^2 \quad \text{.....(4)}$$

to our observations by the method of least squares; that is, to find the best values of A, B and C in equation (4) which are related to the constants of equation (3) as follows:

$$\left.\begin{array}{lll} C = -1/2\sigma^2 & & \sigma^2 = -1/2C \\ B = \xi/\sigma^2 & & \xi = -B/2C \\ A = k - \xi^2/2\sigma^2 & \text{or} & k = A - B^2/4C \\ & & \eta = \text{antilog}_e\, k \end{array}\right\} \quad \text{.....(5)}$$

Let x, y now denote the co-ordinates of each of the n observed points (average points in the 10-day periods), so that

$\Sigma x = x_1 + x_2 + x_3 + \ldots\ldots\ldots\ldots + x_n$, and so on.

Then, for best fit, we have the well known result:

$$\left.\begin{array}{l} An + B\Sigma x + C\Sigma x^2 = \Sigma y \\ A\Sigma x + B\Sigma x^2 + C\Sigma x^3 = \Sigma xy \\ A\Sigma x^2 + B\Sigma x^3 + C\Sigma x^4 = \Sigma x^2 y \end{array}\right\} \quad \text{.....(6)}$$

whose solution, written in the form of determinants, is simply

$$A = \frac{\begin{vmatrix} \Sigma x & \Sigma x^2 & -\Sigma y \\ \Sigma x^2 & \Sigma x^3 & -\Sigma xy \\ \Sigma x^3 & \Sigma x^4 & -\Sigma x^2 y \end{vmatrix}}{\begin{vmatrix} n & \Sigma x & \Sigma x^2 \\ \Sigma x & \Sigma x^2 & \Sigma x^3 \\ \Sigma x^2 & \Sigma x^3 & \Sigma x^4 \end{vmatrix}} \quad B = \frac{\begin{vmatrix} n & \Sigma x^2 & -\Sigma y \\ \Sigma x & \Sigma x^3 & -\Sigma xy \\ \Sigma x^2 & \Sigma x^4 & -\Sigma x^2 y \end{vmatrix}}{\begin{vmatrix} n & \Sigma x & \Sigma x^2 \\ \Sigma x & \Sigma x^2 & \Sigma x^3 \\ \Sigma x^2 & \Sigma x^3 & \Sigma x^4 \end{vmatrix}} \quad C = \frac{\begin{vmatrix} n & \Sigma x & -\Sigma y \\ \Sigma x & \Sigma x^2 & -\Sigma xy \\ \Sigma x^2 & \Sigma x^3 & -\Sigma x^2 y \end{vmatrix}}{\begin{vmatrix} n & \Sigma x & \Sigma x^2 \\ \Sigma x & \Sigma x^2 & \Sigma x^3 \\ \Sigma x^2 & \Sigma x^3 & \Sigma x^4 \end{vmatrix}} \quad -1 \quad (7)$$

This permits us to determine A, B and C quickly, and hence to compute σ, ξ, and k from equation (5). These quantities, as we have seen, define respectively the time of the "migration peak," the most likely number of birds to be seen at that time (on an "instantaneous" visit), and the extent to which the migration is spread out over the days.

*Hald (1952) has apparently given an alternative method, but I have not yet seen this work.

It seemed likely that it would be worth while to make these computations only for a few cases—for ducks (all species lumped together) in spring, for ducks in fall, and for scaup (both species lumped together but believed to be chiefly Lesser Scaup) in spring. For other species there are not enough individuals or enough observations to be very satisfactory. Observations every day for 10 years would probably provide enough material for a fair estimate of a dozen or more species of ducks, for the Canada Goose and Whistling Swan, and for several species of shore birds.

	Peak of migration (ξ)	Individuals at peak (η)	Standard deviation (σ)
Ducks in spring (individuals)	April 6	37.11	24.1 days
Ducks in fall	October 16	10.89	24.5 days
Scaup in spring	April 13	20.49	18.4 days
Species in spring	April 6	6.74	32.1 days

From this it follows that scaup in spring are just one week late compared with ducks in general (including themselves), or almost two weeks late compared with all species of ducks other than scaup.

Again, the ducks are equally "spread out" in time on the fall migration and in spring, as shown by the standard deviations of 24.1 and 24.5 days respectively.

However, the period in spring that is rich in species is longer than the period that is rich in individuals, as shown by standard deviations of 32 and 24 days respectively. This may be due in part to our having included species other than ducks proper in our analysis of the species-richness.

One other point may be worth noting. The period from April 6 to October 16 is very close to six months, so that the ducks do in fact divide their time fairly equally between their summer and winter homes. This would be a fundamental requirement if we wished to graduate the data as an annual rhythmic sine curve; the requirement is in fact met, but the other requirements, previously referred to, are not, and hence we have rejected this method of graduation.

The "peak of migration," or ξ-value, is not strictly a local phenomenon. When a maximum number of birds are observed at Oneida, it presumably means that a maximum number of birds are shifting from north to south, or vice versa, and this would appear to be a phenomenon continental in scope, or at any rate valid for a very large region.

There is another standard deviation (σ_2) that might be computed. What we have computed above is the "spread of the migration," that is, the dispersion *in time* of the birds' passage. We can, however, also make an estimate of the spread *in numbers* likely to be observed at any time during the migration. For a 20-day period near the peak of migration this comes out approximately as follows:

	Individuals at peak	Standard deviation (σ_2)	0.6745 σ_2
Ducks in spring	37	23	15.6
Scaup in spring	21	20	13
Species in spring	7	3	2

In other words, 50 per cent. of all ducks pass through Oneida in spring within a period of about 32 days, from March 21 to April 22. One quarter of them pass through before March 21, and one quarter after April 22. (Fifty per cent. of the area of a Gaussian curve lies between plus and minus 0.6745 σ_2 from the peak.) And if we make a large number of random visits to Oneida in the peak periods of spring, half our visits should result in our observing a population of ducks between 22 and 52 individuals, a population of scaup between 8 and 34 individuals, and a number of species between 5 and 9.

The high standard deviations (σ_2) mean that we may, not seldom, draw something approximating a blank and on other occasions run into a great concourse of individuals and species, since an occasion with a $2\sigma_2$ deviation is by definition not a really rare event. This high σ_2 value is what makes the scatter-plots so hard to interpret until they have been averaged down to 10-day intervals. The reason for the high values is probably simple. For the wildfowl to travel it must not only be the right season but also the right weather, and the weather is highly variable. The influence of weather upon migration has been studied for many decades, and is an active subject at the present time [Gunn and Crocker (1951), Mayfield (1947), Bagg (1950), Bennett (1952), and many others].

Integral of the curve. Suppose we visit Oneida once every day in the migration period, and count the ducks. We may count the same individual duck two or more times, if it is present on more than one day. On the other hand, some ducks may come and go between two of our consecutive visits, so that we never see them. These two factors tend to cancel one another, but one may well be much greater than the other, so that the cancellation is far from perfect. What we finish with in any case is a daily count of birds, and if we add up all these counts throughout the migration, we get an estimate of the birds × days or "bird-days" *per season*. Call this Q.

$$\text{Now} \int_{-\infty}^{+\infty} \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(x-\xi)^2}{2\sigma^2}} . dx = 1$$

$$\text{or} \int_{-\infty}^{+\infty} \eta . e^{\frac{-(x-\xi)^2}{2\sigma^2}} . dx = \sqrt{2\pi} . \sigma . \eta = 2.5 \sigma . \eta = Q \quad \ldots(8)$$

Hence we have

	Ducks in spring	Scaup in spring	Ducks in fall
Q =	2240	940	665

From this it follows that 42 per cent. of all ducks seen at Oneida in the spring will be scaup. Also, the number of ducks using Oneida in the fall is about 30 per cent. of the number using it in spring. Or, seeing that the birds going south in the fall are necessarily more numerous than those going north in the spring, the efficiency of Oneida Dam in the fall is considerably less than 30 per cent. of its efficiency in the spring.

These figures may be compared with the actual observations over the four-year period. In the spring, 3335 duck-days were counted, of which 1323, or 40 per cent. were scaup-days. In the fall we had 622 duck-days, but this must be corrected for the fact that the number of visits was not identical in spring and fall (120 and 80 respectively). Adjusting this to equal numbers of visits would give a figure of 933 or 27 per cent., which is close to the calculated 30 per cent. The 40 per cent. figure above refers to identical visits, and is close to the theoretical value of 42 per cent. Thus both figures agree well with theoretical estimates.

CONCLUSION

The data we have so far accumulated are sufficient, with a few species, to indicate with fair accuracy the peaks of the migrations, but they are not sufficient to define with any real certainty the normal beginning and end of a migration. However, it may be interesting, though unimportant, to list the earliest and latest dates so far observed, for those species that have been observed often enough. There are two reasons for this. One is that a few of the dates already lie outside the range given by Todd. The other is that it provides targets to be shot at in their turn.

In what follows I have included a few observations made at the Carrie Dam on the grounds of the Preston Laboratories, and a very few from other local ponds and dams of Butler County. Although I should have preferred to use a single "net" such as Oneida Dam alone, it seemed to me that a slightly better picture of the skyways was presented by utilizing the other data also, in this particular appendix (Table 3).

Since we have decided that both spring and fall migrations appear to be represented by Gaussian curves, it follows that it is only a question of making enough observations and examples will be found that fall outside the limits established by a *few* observations. In other words, all "records" set in the present report must be expected to fall, and to fall, for the most part, rather promptly.*

*Since this report was completed, part of the spring migration of 1953 has been observed, and six species were observed earlier than in any previous year, and one species later than in any previous year, thus bearing out the prophecy.

TABLE 3. EARLIEST AND LATEST DATES, ON SPRING AND FALL MIGRATION, OF BIRDS THAT HAVE BEEN SEEN ON AT LEAST FOUR MIGRATIONS OUT OF EIGHT. (ONEIDA AND OTHER LOCAL DAMS)

	1949		1950		1951		1952	
Species	S	F	S	F	S	F	S	F
Common Loon	Apr. 1	Oct. 27 Nov. 25	Apr. 1 Apr. 27	Oct. 21 Nov. 17	Apr. 17 May 18	Nov. 4 Nov. 24	Mar. 19 May 11	Oct. 19
Horned Grebe	Apr. 1		Mar. 28 Apr. 23	Nov. 23		Oct. 28 Nov. 4	Mar. 29	Nov. 13
Pied-billed Grebe	Mar. 25	Sept. 1 Oct. 30	Mar. 28 May 6	Oct. 21 Nov. 24	Feb. 16 May 12	Aug. 20	Mar. 20 Apr. 20	Sept. 3 Nov. 23
Great Blue Heron	Mar. 22	Sept. 10 Oct. 22	Apr. 11 Apr. 27		Apr. 1	Aug. 12	Mar. 23	Sept. 3
Whistling Swan	Apr. 1 Apr. 23		Mar. 29		Apr. 25	Nov. 3 Nov. 17		(Oct. 29 overhead)
Canada Goose			Mar. 19		Mar. 26		Mar. 27	Oct. 13
Mallard	Mar. 19	Sept. 10	Feb. 12 May 1	Nov. 11	Feb. 17	Oct. 8		Sept. 28
Black Duck	Feb. 23	Sept. 10 Oct. 30	Feb. 12 May 5	Aug. 30	Feb. 20 May 14	Sept. 14	Mar. 9	Nov. 20
Gadwall	Feb. 20				Mar. 22		Mar. 20 May 11	Sept. 3
Baldpate	Feb. 21	Sept. 14 Nov. 4	Mar. 1 May 1		Feb. 27	Sept. 14 Nov. 18	Mar. 20	
Pintail	Mar. 18?	Aug. 29	Mar. 15			Oct. 8 Nov. 18	Mar. 20	Sept 21
Green-winged Teal		Nov. 15 Nov. 20			Mar. 21 May 6	Oct. 28 Nov. 4		Sept. 21?

Species	1949 S	1949 F	1950 S	1950 F	1951 S	1951 F	1952 S	1952 F
Blue-winged Teal	Mar. 27	Oct. 29 Nov. 19	Mar. 28 May 6		Mar. 25 May 12	Aug. 12	Apr. 20	Sept. 14
Redhead	Feb. 20		Mar. 1		Feb. 28	Nov. 18	Feb. 9	
Ring-necked Duck	Mar. 18?		Mar. 19 Apr. 27	Nov. 4 Nov. 11	Feb. 19	Oct. 18	Feb. 9 Apr. 20	Oct. 20
Scaup	Mar. 24		Mar. 1 May 13	Nov. 4 Nov. 23	Mar. 21 May 18	Nov. 22	Mar. 15 May 11	Oct. 20
American Golden-eye	Feb. 20		Mar. 12		Feb. 16	Nov. 17 Nov. 23	Feb. 9	Oct. 20
Buffle-head	Mar. 25	Oct. 29 Nov. 27	Mar. 29 May 1	Nov. 5 Nov. 11	Apr. 18	Oct. 28 Nov. 4	Mar. 21	
Old-squaw	Apr. 27		Apr. 23		c Apr. 25		Apr. 6	
Ruddy Duck	Apr. 13	Oct. 30 Nov. 23	Apr. 11 May 6	Nov. 5 Nov. 23	c Apr. 25	Oct. 28 Nov. 18	Mar. 21 May 13	Oct. 17
Hooded Merganser	Mar. 22	Nov. 4? Dec. 4	Mar. 15 Apr. 17		Mar. 22 Apr. 18	Nov. 3 Nov. 18	Mar. 13 Apr. 20	Oct. 4
Red-breasted Merganser	Mar. 14	Nov. 20	Mar. 12 May 1		Apr. 1 Apr. 19	Oct. 28	Feb. 9 Apr. 15	
American Coot	Mar. 18	Sept. 10? Oct. 30	Mar. 24 May 5	Oct. 29 Nov. 23	Apr. 17 May 12	Oct. 6 Nov. 24	Mar. 20 Apr. 20	Oct. 4
Greater Yellow-legs	Apr. 9	Sept. 1? Nov. 20	Apr. 20 May 1		Apr. 19 May 14	Oct. 18 Nov. 4		Oct. 4 Nov. 2
Lesser Yellow-legs		Sept. 18	Apr. 20		May 12	Sept. 14		Sept. 10 Sept. 28?
Bonaparte's Gull	Mar. 24		Mar. 29 Apr. 23		Apr. 1		Apr. 13 Apr. 20	

These results may perhaps be usefully condensed to give the earliest and latest dates so far observed for migrant species in spring and fall, as follows:

Common Loon	March 19—May 18
	October 19—November 25
Horned Grebe	March 28—April 23
	November 13—November 23
Pied-billed Grebe	February 16—May 12
	September 1—November 24
Great Blue Heron	March 22—April 27
	August 12—October 22
Whistling Swan	March 29—April 25
	October 29—November 17
Canada Goose	March 19—March 27
	October 13
Mallard	February 12—May 1
	September 10—November 11
Black Duck	February 12—May 14
	August 30—November 20
Gadwall	February 20—May 11
	September 3
Baldpate	February 21—May 1
	September 14—November 18
Pintail	March 15—March 20
	August 29—November 18
Green-winged Teal	March 21—May 6
	September 21—November 20
Blue-winged Teal	March 25—May 12
	August 12—November 19
Redhead	February 9—March 1
	November 18
Ring-necked Duck	February 9—April 27
	October 18—November 11
Scaup	March 1—May 18
	October 20——November 23
American Golden-eye	February 9—March 12
	October 20—November 23
Buffle-head	March 21—May 1
	October 28—November 27
Old-squaw	April 6—cApril 25
	(no Fall observations)
Ruddy Duck	March 21—May 13
	October 17—November 23
Hooded Merganser	March 13—April 20
	October 4—December 4
Red-breasted Merganser	February 9—May 1
	October 28—November 20

Coot	March 18—May 12
	?September 10—November 24
Greater Yellow-legs	April 9—May 14
	?September 1—November 20
Lesser Yellow-legs	April 20
	September 10—?September 28
Bonaparte's Gull	March 24—April 23
	(no Fall observations)

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